

L2

NAVAL POSTGRADUATE SCHOOL Monterey, California

AD-A273 191



THESIS
SEP 10 1993

THESIS

MEDIA SELECTION FOR THE DEVELOPMENT OF A
HYPERMEDIA/MULTIMEDIA INSTRUCTIONAL MODEL
FOR THE NAVY'S 76mm GUN

by

Robert P. Benjamin, Jr.
and
Ira Spondre

September 1993

Thesis Advisor
Co-Advisor

Kishore Sengupta
B. Ramesh

Distribution authorized to DoD and DoD contractors only; Critical Technology; 1 Sept. 1993. Other requests for this document must be referred to Superintendent, Code 043, Naval Postgraduate School, Monterey, CA 93943-5000 ~~via the Defense Technical Information Center, Cameron Station, Alexandria, VA 22304-6145.~~

92PX 93-29250



93 11 29 124

REPORT DOCUMENTATION PAGE			Form Approved OMB No. 0704	
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instruction, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188) Washington DC 20503.				
1. AGENCY USE ONLY (Leave blank)		2. REPORT DATE 3 Sep 1993		3. REPORT TYPE AND DATES COVERED Master's Thesis
4. TITLE AND SUBTITLE: MEDIA SELECTION FOR THE DEVELOPMENT OF A HYPERMEDIA/MULTIMEDIA INSTRUCTIONAL MODEL FOR THE NAVY's 76mm GUN			5. FUNDING NUMBERS	
6. AUTHOR(S): Robert P. Benjamin, Jr. and Ira Spondre				
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Postgraduate School Monterey CA 93943-5000			8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)			10. SPONSORING/MONITORING AGENCY REPORT NUMBER	
11. SUPPLEMENTARY NOTES The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government.				
12a. DISTRIBUTION/AVAILABILITY STATEMENT Distribution authorized to DoD and DoD contractors only. Critical Technology, 1 Sept. 1993. Other requests for this document must be referred to Superintendent, Code 043, Naval Postgraduate School, Monterey, CA 93943-5000 via the Defense Technical Information Center, Cameron Station, Alexandria, VA 22304-6145			12b. DISTRIBUTION CODE D	
13. ABSTRACT (maximum 200 words) This thesis examines various literature to help understand the effects that different types of media, when used alone or in combination, have on the learning process and proposes a design guideline for a hypermedia/multimedia system for the Navy's 76mm gun. Additionally, hypermedia/multimedia user interface guidelines and screen design principles are addressed as well as a comparison of three existing military media selection models. Research suggests that capabilities of a particular medium, in conjunction with methods that take advantage of these capabilities, interact with and influence the ways learners represent and process information and may result in more or different learning when one medium is compared to another for certain learners and tasks (Kozma, 1991, p. 179).				
14. SUBJECT TERMS Media selection, Multimedia, Hypermedia, Perception, Cognition			15. NUMBER OF PAGES 93	
			16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified	20. LIMITATION OF ABSTRACT UL	

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. Z39-18

Distribution authorized to DoD and DoD contractors only; Critical Technology; 1 Sept. 1993. Other requests for this document must be referred to Superintendent, Code 043, Naval Postgraduate School, Monterey, CA 93943-5000 ~~via the Defense Technical Information Center, Cameron Station, Alexandria, VA 22304-6145.~~

Media Selection for the Development of a Hypermedia/Multimedia Instructional Model
for the Navy's 76mm Gun

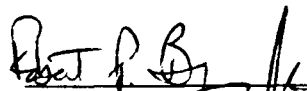
by

Robert P. Benjamin, Jr.
Lieutenant, United States Navy
B.S., Auburn University, 1987
and
Ira Spondre
Captain, United States Marine Corps
B.S., University of Idaho, 1984

Submitted in partial fulfillment
of the requirements for the degree of


MASTER OF SCIENCE IN INFORMATION TECHNOLOGY MANAGEMENT
from the
NAVAL POSTGRADUATE SCHOOL
September 1993


Authors:



Robert P. Benjamin, Jr.


Ira Spondre

Approved by:


Kishore Sengupta, Advisor


B. Ramesh, Co-Advisor


David R. Whipple, Chairman
Department of Administrative Sciences

ABSTRACT

This thesis examines various literature to help understand the effects that different types of media, when used alone or in combination, have on the learning process and proposes a design guideline for a hypermedia/multimedia system for the Navy's 76mm gun. Additionally, hypermedia/multimedia user interface guidelines and screen design principles are addressed as well as a comparison of three existing military media selection models.

Research suggests that capabilities of a particular medium, in conjunction with methods that take advantage of these capabilities, interact with and influence the ways learners represent and process information and may result in more or different learning when one medium is compared to another for certain learners and tasks (Kozma, 1991, p. 179).

DTIC QUALITY INSPECTED 8

Accession For	
NTIS CRA&I	<input type="checkbox"/>
DTIC TAB	<input checked="" type="checkbox"/>
Unannounced	<input type="checkbox"/>
Justification	
By	
Distribution	
Availability Codes	
Dist	Avail and/or Special
D-16	

Table of Contents

I. INTRODUCTION	1
A. BACKGROUND	1
B. TECHNOLOGY	2
C. PURPOSE OF PAPER	2
D. ORGANIZATION OF PAPER	3
II. MEDIA SELECTION	5
A. INTRODUCTION	5
B. LEARNING VS COMPREHENSION	5
1. Human Information Processing	7
2. Perceptual Processor	8
3. Cognitive Processor	8
4. Working Memory	9
5. Long-Term Memory	10
6. Learning And Retrieval	11
a. Decay	12
b. Limiting	12
C. DEFINITION OF MEDIA	13
1. Symbol Systems	13
2. Processing Capability	14
D. TYPES OF MEDIA AND LEARNING	14
1. Text	16
2. Text/Pictures	18
3. Full Motion Video/Audio	20
E. EXISTING MILITARY MEDIA SELECTION MODELS	22
1. Tactical Analysis And Evaluation Group (Taeg)	23
2. Training Effectiveness, Cost Effectiveness Prediction (Tecep)	24
3. Mil-T Model	27
4. Critique Of Existing Models	29
F. CONCLUSION	31
III. TASK DEFINITION/PRELIMINARY DESIGN	33
A. INTRODUCTION	33

B. DEFINITION OF MULTIMEDIA	33
C. DEFINITION OF HYPERTEXT	34
D. USER INTERFACE GUIDELINES	36
E. SCREEN DESIGN PRINCIPLES	38
F. TASK DEFINITION	39
G. SCREEN PRESENTATIONS	43
1. Screen Presentations: Text	46
2. Screen Presentations: Text/Pictures	46
3. Screen Presentations: Full Motion Video	47
H. SYSTEM COMPONENTS	47
1. System Hardware	47
a. SUN Desktop SPARCstation 10	47
b. Parallax XVIDEO Card	48
c. Microphone/Speaker	49
d. Sony LDP-1550 Videodisc Player	49
2. System Software	49
a. UNIX Operating System/OpenWindows	49
b. MAEstro Authoring System	49
c. FrameMaker	51
IV. CONCLUSIONS/RECOMMENDATIONS/PROBLEMS ENCOUNTERED	53
A. CONCLUSIONS	53
B. PROBLEMS ENCOUNTERED	57
C. RECOMMENDATIONS FOR FUTURE DEVELOPMENT	59
APPENDIX A	60
APPENDIX B	67
APPENDIX C	77
LIST OF REFERENCES	78
BIBLIOGRAPHY	81
INITIAL DISTRIBUTION LIST	86

I. INTRODUCTION

A. BACKGROUND

The rapid growth in computer technology has precipitated the proliferation of instructional multimedia presentations. A designer's problem, is to choose presentations of media that are most appropriate for a given situation. There is a large body of often conflicting media selection information, most of which is based upon psychological studies and learning theory.

" To say that media can motivate, reinforce, inform, guide, assist in recall, enhance retention, and the like, is to say only that media can be used in instruction." (Olson, 1974, p. 384) Each media possesses a particular symbol system that is used to convey information that hopefully, will transmit the educational objective to the user. As such, it is symbol systems, not technology, that are the underlying factors for media selection. (Olson, 1974, pp. 384-385)

The initial research for this paper was conducted as part of a larger project and done in conjunction with Filbert and Weatherspoon (1993) with the intention of creating a multimedia training module for the Navy's 76mm gun. Due to software and hardware limitations the module was not completed beyond a preliminary prototype. What is presented are the results of the literature review conducted for development of the module. As such, this paper explores the human information processing system as it

relates to media selection. In addition, three military media selection models are evaluated and compared.

B. TECHNOLOGY

Technology has enabled the transition from a single teacher multiple student setting to one of one-on-one, human-computer interaction in a multimedia/hypermedia environment. For this paper the definition of technology embodies the entire range of available processors and media tools.

The introduction of CD-ROM and laser disc players, along with the availability of large chunks of cheap memory, has led to the development of a myriad of interactive multimedia presentations. Hapeshi and Jones (1992), point out that "mixed-media" systems have been available for many years in many forms and that their proliferation has always been driven by technology (Hapeshi and Jones, 1992, p. 81).

If current trends continue, and there is every indication that they will, technology will not be the limiting factor in the development of multimedia learning modules. Increases in processing speeds and storage capacity, combined with improved display capabilities, will enable quicker response times, more complex presentations and greatly enhanced video, graphic and other media capabilities. Use of fiber optics, with its virtually unlimited bandwidth, will also enable multimedia presentations to be used effectively and efficiently in the growing networking environment.

C. PURPOSE OF PAPER

What makes a multimedia presentation more affective than other methods of teaching? Is there a single media selection model available that will enable designers to create an

affective training document in every context? How do the various media effect the perceptual and cognitive aspects of learning and retention? These are the key questions that must be addressed by designers of instructional systems.

"Users vary widely in general intellectual ability, experience with computers, specific knowledge of the computer, cognitive style, and perceptual motor skills" (Card, Moran and Newell, 1983, p. 404). "Other performance measures are possible, such as performance under extreme conditions (fatigue and stress) and the performance demands on the user's memories (working memory and Long-Term memory). Finally, there are variables concerning the user's subjective feeling about the system" (Card, Moran and Newell, 1983, p. 404).

"To predict the performance of a system, the designer must construct a specific performance model from the system's structural specifications and then use the model to generate a prediction..." (Card, Moran and Newell, 1983, p. 405). The development of any presentation, therefore, must look beyond available technical capabilities, and focus on the abilities of the user to perceptually and cognitively process the presentation. The task of the designer then, is to choose a presentation method that compliments the users' abilities. This thesis addresses the perceptual and cognitive aspects of media selection as they pertain to learning and comprehension in a multimedia environment.

D. ORGANIZATION OF PAPER

Chapter II examines the subject of media selection and how it relates to learning and comprehension. Numerous studies were explored to help understand the effects that different types and combinations of media might have on the learning process. Also, three

existing military media selection models are discussed briefly, followed by a short comparative critique.

Chapter III discusses user interfaces, screen development and a possible task, the 76mm, Mod 0, R-1, Planned Maintenance System (PMS) Check, for future multimedia development. Also presented are a brief listing and description of the hardware and software used in initial development efforts.

Chapter IV presents conclusions and recommendations for possible future development.

II. MEDIA SELECTION

A. INTRODUCTION

This explores the subject of media selection as it relates to learning and comprehension. Several studies were examined to help understand the effects different types of media, when used alone or in combination, have on the learning process. The chapter concludes with a comparison of three military media selection models.

B. LEARNING VS COMPREHENSION

When evaluating combinations of media, the objective is to choose that combination that can be effectively used to increase a user's learning and comprehension. A key question then is, how do various media, when combined to form multimedia presentations, affect the perceptual and cognitive aspects of learning and comprehension?

While the differences are subtle, there is a distinction between learning and comprehension. Learning can be viewed as the act of gathering knowledge or information intended to modify current behaviors or to develop new behaviors, while comprehension, on the other hand, requires a full understanding of a given topic (Merriam-Webster, 1991). While most people have little difficulty in learning, comprehension of any underlying meanings or connections between temporally or spatially placed facts or information is dependent upon the user's level of cognitive ability (Glaser and Bassok, 1989, p. 634).

Kozma (1991) suggests a medium's ability to enhance the learning experience is dependent not only upon the task and the user's learning capabilities, but also upon the

ability of the instructional design to fit the medium's capabilities to those required by the user. Kozma further suggests that presentations must be designed to aid the user in creating mental representations that are best suited to the user's processing abilities (Kozma, 1991, pp. 179-180).

There is a large body of research on why people learn. Card, Moran and Newell define what they call the "Rationality Principle" for learning. This principle states that "a person acts so as to attain his goals through rational action, given the structure of the task and his inputs of information, and bounded by limitations on his knowledge and processing ability:

Goals + Task + Operators + Inputs + Knowledge + Process - Limits = Behavior."
(Card, Moran and Newell, 1983. p. 86)

Glaser (1984) indicates that novices may have difficulties in problem solving due to inadequate knowledge bases. A user's ability to process information and integrate knowledge is dependent upon his/her stage of learning (Glaser and Bassok, 1989, p. 635). Is it possible to structure media to enhance learning and comprehension throughout groups with little or no knowledge of the subject area; or is the intellectual capacity required for comprehension beyond the scope of media selection? The research presented in this thesis suggests that the choice of media for a given presentation can in fact enhance learning and comprehension.

While the purpose of this paper is to use media selection techniques to develop a multimedia training module for the Navy's 76mm gun, any discussion of media selection would be incomplete without an understanding of human information processing and

memory theory. The following sections discuss information processing and how various media affect human perceptual and cognitive processors.

1. Human Information Processing

Card, Moran and Newell define what they call "The Model Human Processor" when describing how people process information (see Figure 1). They divide the human processing system into three subsystems: the perceptual system, the motor system and the cognitive system (Card, Moran and Newell, 1983, p. 24).

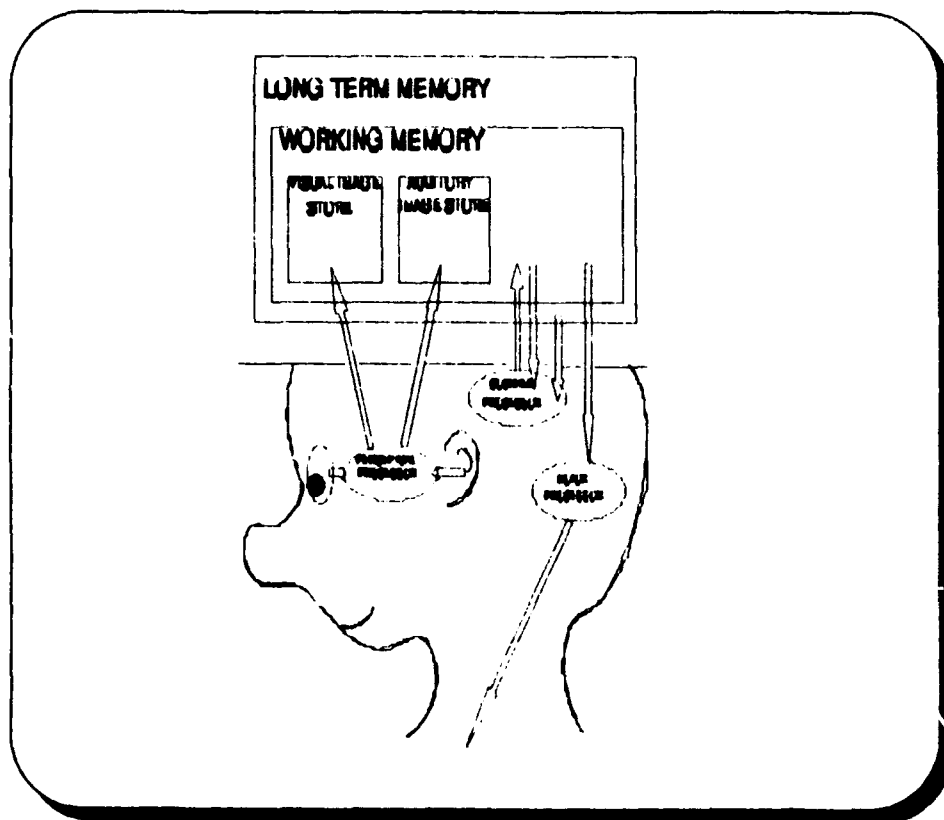


Figure 1. Human Information Processing.

Sensory information flows from the Perceptual Processor to Working Memory. Human Information Processing is the Recognize-Act Cycle of the Cognitive Processor (Card, Moran and Newell, 1983, p. 26).

The following sections discuss the perceptual and cognitive processing systems and their effects on Long-Term and working memory.

2. Perceptual Processor

In learning any task, perception is a key element. The perceptual processor codes images for later use. There is no guarantee that because a person is watching a presentation that he/she is perceiving what was intended. During any presentation subject's process information as it becomes available. As images are presented at different times in any presentation, the speed of the presentation can have an effect on memory and how images are processed. If the image is presented too fast a person may wait for the image to become clearer or simply process the faulty images (Card, Moran and Newell, 1983, p. 32).

3. Cognitive Processor

Studies conducted by Card, Moran and Newell suggest that the cognitive system is fundamentally parallel in its recognizing phase and fundamentally serial in its action phase. Thus the cognitive system can be aware of many things, but cannot do more than one deliberate operation at a time (Card, Moran and Newell, 1983, p. 42). Numerous other studies have also shown that with practice it is possible to shorten the cycle time of the cognitive processor (Card, Moran and Newell, p. 42). The goal of media selection, therefore, is to minimize the interference in presentations and enable the cognitive processor to process inputs from the perceptual processor effectively.

4. Working Memory

Working memory can be viewed as that portion of Short-Term memory that retrieves information from Long-Term memory for comparison and evaluation (Gagne' and Glaser, 1987, pp. 54-55). As such, working memory can be viewed as holding chunks of intermediate operands, products and representations input from the perceptual processor, Long-Term memory, and the cognitive processor (Card, Moran and Newell, 1983, p. 36).

Gagne' and Glaser (1987) view working memory as performing three functions (see Figure 2). The first is rehearsal, where repetition is used to enable items in working memory to be retained for longer periods of time and for transfer to Long-Term memory through the process of integration. Integration is the second function and is the process where newly acquired information is coded for transfer to Long-Term memory. The third function is Matching and Recognition. This function entails comparing incoming information with information stored in Long-Term memory (Gagne' and Glaser, 1987, p. 55).

Working memory is limited in both the time an item can be held and in the number of items that can be held in working memory. As such, when designing presentations the number of steps or stimuli presented must be limited so as not to exceed the capacity of the user's working memory (Gagne' and Glaser, 1987, p. 57).

5. Long-Term Memory

Long-Term memory is that portion of memory that holds the user's mass of available knowledge (Card, Moran and Newell, 1987, p. 39). Information that is transferred to Long-Term memory from working memory is encoded semantically so it may be related to information already present in Long-Term memory (Sanders and McCormick, 1993, p. 68). As such, Long-Term memory can be viewed as related chunks of information that consist of facts as well as procedures. Card, Moran and Newell

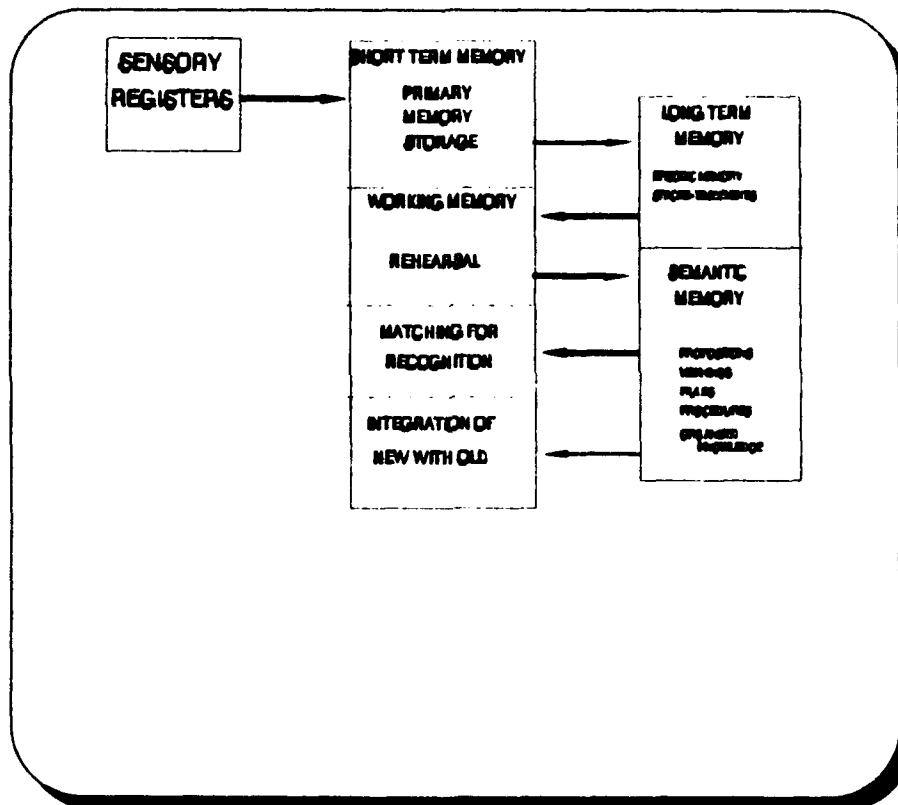


Figure 2. Information Flow in Working and Long-Term Memory (Gagne' and Glaser, 1987, p. 55).

assert that these chunks are retrieved from Long-Term memory by association with information in working memory and that once an item is in Long-Term memory it is there

permanently. They suggest that as time passes, forgetting is simply the inability to find associations for the desired information (Card, Moran and Newell, 1987, pp. 39-40).

6. Learning and Retrieval

Studies conducted by Card, Moran and Newell on how many file names programmers could recall when verbally given one syllable file names, suggests that meaningful items of information can be remembered up to 10 times longer than non meaningful items of information due to chunk sizes and are easier transferred to long term memory (Card, Moran and Newell, 1983, pp. 77-79). This is also supported in other studies reported by McDowd and Botwinick (McDowd and Botwinick, 1984, pp. 167-168).

The crux of the problem in learning is to transfer as much information from working memory into long-term memory as possible. We therefore must create the proper retrieval cues in memory to permit access to the proper data by enabling the recall of the appropriate chunk(s). "The more associations an item has, the greater its probability of being retrieved" (Card, Moran and Newell, 1983, pp. 40-41).

Similarly, the pacing of learning affects memory and recall. People must allow sufficient time to develop links and cues to allow information transfer to long term memory with higher probability of retrieval (Card, Moran and Newell, 1983, p. 41). Card, Moran and Newell state, that memory operates "... as a fast-read, slow-write system" and further imply " ...storing new chunks in Long-Term memory thus requires a fair amount of time and several Long-Term memory retrievals" (Card, Moran and Newell, 1983, p. 41). This implies that practice is necessary for efficient transfer to Long-Term memory.

McDowd and Botwinick reported on studies of rote and gist memory. They cite findings from a study that compared recall of "pair associated" or "serial word lists" between elderly participants and young adults. The findings indicate that how well a subject recalls information is not only dependent upon the types of information presented but also on the presentation methods (McDowd and Botwinick, 1984, pp. 167-168).

a. Decay

Decay rates play a large part in memory theory. Media selection would not, in and of itself, be critical to instructional design if information from all types of media decayed at the same rate, but unfortunately this is not the case. Besides fitting the media to the person, we must also attempt to choose the appropriate keys to enhance recall. How information is presented will play a part in decay rates.

Video and still images, as well as auditory presentations, are processed differently in memory. In this context, it has been determined that memory is searched differently for each type of media (Card, Moran and Newell, 1983, pp. 24-32).

b. Limiting

There are limits to both working memory and Long-term memory. Studies done in the 1950's by Miller (1956) suggested a capacity of 7 plus or minus 2 items for working memory. Recent studies by Card, Moran and Newell, as well as others, suggest a smaller capacity in the range of 2.5 - 4.1 items (Card, Moran and Newell, 1983, p. 93). These limits must be carefully considered when developing a multimedia presentation so as not to overload a user's memory capacity (Gagne' and Glaser, 1987, p. 67).

C. DEFINITION OF MEDIA

What is media? Kozma (1991) suggests that "media can be defined by its technology, symbol system, and processing capabilities" (Kozma, 1991, p. 180).

1. Symbol Systems

Before exploring the selection of media for a given task we must first explore how learning and comprehension are effected by media. Symbol systems convey information to the user and as such are the essence of media selection. Olson defines symbol systems as "a set of symbols so organized as to form a system of interrelated options which are correlated with a field of references; e.g., language, music, numbers" (Olson, 1974, p. 12). The purpose of media selection is to select the appropriate presentation for the task. Salomon (1974,1979) points out that not all media possess the same information transfer ability and that different symbol systems are processed differently in memory. Salomon further states "media's ways of structuring and presenting information-that is, their symbol-systems-are media's most important attributes when learning and cognition are considered and should serve as the focus of our inquiry" (Salomon, 1979, p. 216). This, therefore, implies that for effective information transfer the media chosen must fit the task as well as the learning abilities of the users.

Symbol systems carry the content or message of the media and as such, some contents can be carried by different/all media. In turn, contents determine how our information processing system reacts to either retain or not to retain the information contained in the presentation (Salomon, 1979, pp. 16-17). This is evident in our day-to-day encounters with various media. We may read an article in the newspaper in the

morning and later that day we may see the same story on the television. Dependent upon how we process the different symbol systems, we may get more information from one presentation than the other.

This leads us to the conclusion that even though the content may be the same, our ability to process various media effectively is dependent on the symbol system employed. Nugent believes that researchers have failed to recognize that each media provides stimuli through varied symbol systems that, when combined, strengthen the learning characteristics of each individual media (Nugent, 1982, p. 165). Nugent further indicates an important and often overlooked attribute of multimedia is that combinations of media provide the user with associations of symbol systems. These associations of symbol systems provide users with various linguistic and iconic codes that are processed and interpreted differently in memory by the individual user (Nugent, 1982, p. 164).

2. Processing Capability

The way in which media influences the human processing capacity should be evaluated so that the chosen media complements the capabilities of the user. Learners do not possess equal information processing abilities. The processing of presented information is effected by how users have learned in the past and their perceptions as to how the current information fits into their metacognitive knowledge, and just as importantly, their motivation to learn (Kozma, 1991, pp. 181-182).

D. TYPES OF MEDIA AND LEARNING

Does the way we use media influence learning? Is there a relationship between media and learning? Much of the previous research conducted suggests that the selection of the

appropriate medium, when fitted to a specific learner and task, does affect and influence the ways in which people represent and process information (Kozma, 1991, p. 182) (Salomon 1974,1979).

Whether or not a medium's properties and attributes make a difference in learning depends on how those properties and attributes correspond to the particular learning situation--the tasks and learner's involved--and the way the medium's capabilities are used by the instructional design (Kozma, 1991, p. 182).

There are some conflicting views about whether or not "the medium" makes any difference at all in learning. Clark (1983) concluded that "... media do not influence learning under any conditions..." (Clark, 1983, p. 445) and further determined that "media are mere vehicles that deliver instruction but do not influence student achievement any more than the truck that delivers our groceries causes changes in our nutrition" (Clark, 1983, p. 445). However, most other studies do not support Clark's viewpoint. For example, Kozma (1991) established that fitting the medium to the task could influence learning and information processing. Other research suggests that capabilities of a particular medium, in conjunction with methods that take advantage of these capabilities, interact with and influence the ways learners represent and process information and may result in more or different learning when one medium is compared to another for certain learners and tasks (Kozma, 1991, p. 179).

The purpose of media selection is to choose the most appropriate medium in order to allow the perceptual aspects of learning to support the cognitive aspects and to create

reinforcement of the task or subject in such a way as to permit recall of the subject when the material is required.

1. Text

One of the most common media encountered today in a learning environment is text. A distinctive property of text is its stability (i.e., permanently printed orthographic symbols that allow for review or regression anytime). This stability has important implications for how learners process information. Specifically, the stability of text aids in constructing a meaning of the text (Kozma, 1991, p. 183).

In most situations, reading progresses at a regular rate. However, on some occasions, when previous knowledge and skill are lacking, many readers will rely heavily on the stability of text to aid learning and comprehension. In a study by LaBerge and Samuels, to measure the degree of accuracy and automaticity achieved in perceptual and associative learning tasks, they determined that the effort required of weak readers to decode and understand text drew upon cognitive resources that would otherwise be used for comprehension, thus increasing the risk of comprehension/learning failure (LaBerge and Samuels, 1974, pp. 313-314).

Another study reported by Card, Moran and Newell, measuring reading rates and processing ability, concluded that how much the reader takes in per fixation is dependent upon the difficulty of the material and the students cognitive processing ability. If material is conceptually demanding there may be difficulty in cognitive processing (Card, Moran and Newell, 1983, p. 51). But even fluent readers may have difficulty with long or novel words, such as technical terms in an unfamiliar domain. In both cases, readers will use the

stability of text to recover from comprehension failure either by returning to review the information or by reducing the rate at which they are reading (Kozma, 1991, p. 184).

Thus, one of the greatest advantages of text in aiding comprehension is its stability which allows readers to regress over segments of information if necessary.

Perhaps just as important as the use of the stability of text to recover from comprehension failure in difficult situations is the use of stability in conjunction with elaborate memory structures to process large amounts of text within familiar domains (Kozma, 1991, p. 184).

Bazerman (1985) conducted a study in which he interviewed seven professional physicists and observed them reading professional material in their field. Most often their interests were to find information that might contribute to their immediate research goals or to expand their background knowledge of the field. He found these subjects to read very selectively. The subjects would typically read by scanning rapidly over tables of contents and by using certain words to trigger their attention to question a particular title more actively. If a particular term attracted their attention, they would look at other words in the title with the result that about two thirds of the titles more closely examined were subsequently rejected based on this additional information.

Upon identifying an article of interest, they would then read parts of it selectively and nonsequentially, jumping back and forth, reading those sections more carefully that fit their purpose. If they chose to read through a difficult article or section, they would occasionally pause at length to work through the implications of what had been read or read through it several times (Kozma, 1981, pp. 184-185). These results are

also supported by studies of rote and gist memory reported by McDowd and Botwinick. These studies suggest that reading provides for better recall than does audition due to the ability for review of text at the readers pace (McDowd and Botwinick, 1984, pp. 176-177).

The above studies illustrate the relationship between human information processing and the stability of text. Readers slow down to comprehend difficult or important points, and stop or regress to retrieve the meaning of an unfamiliar word or a confusing phrase. They also use their knowledge of the domain and highly developed strategies to read very selectively.

2. Text/Pictures

Combining text and pictures is another widely used tool to invoke learning, but how do readers use pictures to learn? What are the perceptual and cognitive effects of pictures in combination with text? Many studies have been conducted and most conclude that the use of pictures with text increases recall, particularly for poor readers, if the pictures illustrate information central to the text, when they represent new content that is important to the overall message, or when they depict structural relationships mentioned in the text (Kozma, 1991, p. 185). But by what mechanisms does pictures and text influence the learning process?

Rustead and Coltheart (1979) examined the way fourth graders used pictured text to learn about unfamiliar animals. Observations of good readers showed that they spent time initially looking at the pictures and rarely looked at them again once they started reading. They noticed that weaker readers frequently moved back and forth

between the text and pictures (Rustead and Coltheart, 1979, pp. 516-524). This examination suggests that good readers used the pictures to develop an image that would guide their reading and aid in their comprehension. For weaker readers, moving back and forth between pictures and text aided the perceptual processor in building mental models of unfamiliar animals.

Stone and Glock (1981) studied second and third year college students and obtained similar findings. Students used text with or without pictures to learn how to construct a pushcart. The group that used both pictures and text was most accurate in its constructions, making only 18 percent of the errors of the text only group. Eye-tracking data indicated two patterns of picture use. Readers would typically spend the first few seconds examining the picture. Then they would look from text to picture as they progressed, spending an average of more than 80 percent of their time looking at text rather than pictures (Stone and Glock, 1981, pp. 419-426). This is similar to the Rustead and Coltheart study in that the data also suggests that readers initially use the pictures to develop an image that will serve as a mental model of the situation. It also seems that the text delivers the main message while the pictures are used to map the information onto the mental model.

Other research shows how pictures interact with domain knowledge. Hegarty and Just (1989) conducted a study in which college students were tested on mechanical ability. They were either assigned to read a short text or a long text that described a pulley system. The short text only named the components of the system and described how it operated. The long text elaborated on the arrangement and structure of the

components. All text was accompanied by a schematic diagram of the system. Hegarty and Just found that students with low mechanical ability spent more time than the high ability students looking at the schematic when it accompanied the longer text, and that the high ability students spent more time examining the diagram with the shorter text (Hegarty and Just, 1989, pp. 171-194). These results suggest that people low in mechanical ability have difficulty forming mental models from text alone and use diagrams to help in constructing a representation. People with high ability seem to construct this model from prior knowledge and information from the text, with little need to refer to the diagram.

The above studies reveal that if pictures are available, people may refer to them to supplement the text. An initial look at the picture will evoke domain knowledge, for those who have it. In a less familiar domain, readers will move back and forth frequently between text and pictures to clarify the meaning or to help in constructing a mental model.

A designer can use these capabilities in a way that complements the learner's skills and deficiencies. Authors can use the stability of text and pictures to design structures that support and facilitate learning (Kozma, 1991, p. 188). Pictures alone can provide a wealth of information, but to be an effective tool pictures must be used in combination with other media such as print to provide the focus required for efficient learning (Nugent, 1982, p. 165).

3. Full Motion Video/Audio

Motion video differs from text in several ways that affect perceptual and cognitive structures and processes. As with text and pictures, motion video can employ pictures, diagrams, and other symbols, but, in motion video, these symbols are transient

and are able to depict motion. For example, linguistic information can be textual, but more often it is oral and transient. Because linguistic and pictorial symbols are transient, viewers may perceptually process this information in a different way than the serial back-and-forth processing of text and pictures (Kozma, 1991, p. 189).

Research indicates that audio-visual attention is influenced by several factors. One of these factors is called formal features. These features include the use of different types of voices, laughing, sound effects, music, etc. Huston and Wright (1983) found that moment-to moment visual attention may deviate, but that people continually observe the demonstration at a superficial level and that their visual attention is recaptured by certain audio cues. Features that are associated with the onset of visual attention are sound effects, peculiar voices, auditory changes, and visual movement. Features associated with continued viewing are special effects and high physical activity. The offset of visual attention corresponds to the use of long zooms and inactivity (Kozma, 1991, p. 189).

Since motion video has the ability to use both audio and video simultaneously, one question that arises is what is the effect of using these media types, both independently and together, to influence comprehension and learning? Conrad (1964) suggests that acoustic presentations cause interference in working memory as the learner may become confused. Long-Term memory may be more sensitive to interference from written phrases that may have confusing or contradictory meanings. This suggests that what is often thought of as forgetting is simply the inability to retrieve the required information due to external interference in working and long-term memory (Card, Moran and Newell, 1983, pp. 79-81).

A study was conducted by Baggett (1979) in which she was trying to determine how auditory and visual symbol systems work, both independently and together, to influence learning. College students were shown either a silent movie or an equivalent audio version. All students then wrote summaries of certain episodes within the story immediately or after one week. She found that summaries written immediately after viewing the silent movie were about the same as those who only heard it, but that those who viewed it had a more memorable experience. For those who wrote the summaries after a week, students who viewed the story wrote a more complete summary than those who only listened to it (Baggett, 1979, pp. 408-417). This suggests that meaning can be conveyed by either video or audio alone.

However, Baggett concluded that information presented visually and linguistically is represented differently in memory (Baggett, 1989, pp. 101-124). Also, other studies have shown that while visual images decay faster than auditory images it is possible to store more of them in memory. (Card, Moran and Newell, 1983, pp. 29-30).

E. EXISTING MILITARY MEDIA SELECTION MODELS

Both educators and the military have been concerned about choosing the appropriate media to use in a particular instructional setting. For this reason, many media selection models have been developed over the years. Three models that have been developed for the military will be briefly discussed below. While it is true that when these models were initially developed the choices of available media were much more limited than those available today, it is also true that the underlying principles are still appropriate. Although descriptions of some of the models include examples of how they have been

used, it is difficult to find detailed information about situations in which selection models have been employed.

Each of the models performs the following five tasks with varying degrees of detail:

- 1) Identify specific objectives by attribute
- 2) Analyze each specific objective by attribute
- 3) Match instructional attributes against defined media attributes
- 4) Rank media for training effectiveness
- 5) Perform costs/constraints trade-offs

1. Tactical Analysis and Evaluation Group (TAEG)

The TAEG model was developed to apply the concepts of learning theory, economic analysis, and other information acquired by use of the scientific method to the task of training system design (Kribs, Simpson and Mark, 1983, p.11). The model uses a matrix format and consists of nine steps, the first four relating to training effectiveness and the last five relating to cost effectiveness. The training effectiveness steps include (Kribs, Simpson and Mark, 1983, pp. 11-12):

- * *Task Description and Analysis.* Each task to be performed is described in terms of the skills and knowledge required to accomplish that task.
- * *Personnel Characteristics.* Used to determine the starting point for training.
- * *Training Tasks and Training Stages.* Organized to progress through basic skills to advanced skills. Characteristics of the tasks are identified as one of the following 13 task categories:
 - 1) Recalling Facts and Principles
 - 2) Recalling Procedures
 - 3) Non-Verbal Identification

- 4) Non-Verbal Detection
- 5) Using Principles, Interpreting, Inferring
- 6) Making Decisions
- 7) Continuous Movement
- 8) Verbal Detection and Identification
- 9) Positioning and Serial Movement
- 10) Repetitive Movement
- 11) Written Verbalization
- 12) Oral Verbalization
- 13) Other Verbalization, including Signs

* *Determination of Useful Media Options.* The system designer uses the media selection matrix to identify a group of media which satisfy the characteristics of the specific training task.

2. Training Effectiveness, Cost Effectiveness Prediction (TECEP)

The TECEP technique was designed to provide: 1) a set of learning guidelines appropriate to Navy job tasks, and 2) a method for selecting cost effective instructional delivery systems that support the use of those learning guidelines (Braby et al., 1975, p.8).

The TECEP technique is a three-step approach in which training objectives are classified and organized into groups, appropriate learning strategies are defined for each group, media capable of supporting these strategies are identified, and the costs of alternative forms of training are projected. It can be viewed as an aid for an experienced system designer. The third step provides a cost model for projecting the costs of each system alternative and will not be discussed.

The first step is to classify and group the training objectives according to the type of learning algorithm required to accomplish the objective. A learning algorithm is a step-by-step prescription for a student to follow in learning any specific task in a class of learning tasks (Braby et al., 1975, p. 14). The 12 types of learning algorithms are (Braby et al., 1975, pp. 41-44):

- 1) Recalling bodies of knowledge
- 2) Using verbal information
- 3) Rule learning and using
- 4) Decision making
- 5) Detecting
- 6) Classifying
- 7) Identifying symbols
- 8) Voice communicating
- 9) Recalling procedures and positioning movement
- 10) Steering and guiding - Continuous movement
- 11) Performing gross motor skills
- 12) Attitude learning

The second step is to identify instructional delivery systems that support the use of the learning algorithm required for each training objective. This is done by:

- 1) identification of media options, and 2) practicality tests.

In identifying media options, all of the instructional delivery systems with stimulus, response, and feedback capabilities required to support the events in the learning

algorithm are identified. Instructional Delivery System Selection (IDSS) Charts developed for each of the 12 learning algorithms serve as an aid.

An alternate approach can be used to consider systems not included in the charts. Two other aids are provided: 1) a list of 55 generic media characteristics which includes stimulus, response, and feedback characteristics that can be used to describe type of instructional media, and 2) a list describing 89 general types of media that can be incorporated into instructional delivery systems. However, this approach requires expert knowledge of media, the algorithms, and the subject matter.

The practicality tests examine the system for practicality, eliminating impractical systems. Each system is evaluated in terms of the following 11 criteria (Braby et al., 1975, pp. 26-27):

- 1) Marginal technical solution
- 2) State of the art system
- 3) Size of the system
- 4) Interface with existing programs
- 5) Lead time required to produce system
- 6) Budget cycle constraints
- 7) User acceptance of innovations
- 8) Resources for courseware development
- 9) High cost system alternatives
- 10) Learning style of trainees
- 11) Any other applicable constraints

3. Mil-T Model

This media selection model uses a sorting algorithm to divide objectives into categories and then select media alternatives from the following media list (Kribs, Simpson and Mark, 1983, p. 17):

- 1) Workbook
- 2) Mediated Interactive Lecture
- 3) Slide Tape
- 4) Videotape
- 5) Random Access Slide
- 6) Computer Aided Instruction (CAI)
- 7) CAI Simulation
- 8) Simulation
- 9) Actual Equipment

The sorting algorithm contains decision points Q1 through Q5. These points refer to questions 1 through 5. To use the model, one enters the algorithm and proceeds through the decision points (Q1-Q5) answering the questions until a terminal point is reached.

- * Q1 is concerned with the type of learning involved
 - familiarization
 - discriminated recall
 - rule using

- * Q2 is concerned with the level of content
 - familiarization
 - paired associate
 - concept
 - rule
- * Q3 focuses on the minimum critical set of instances the student needs to see small or large
 - small
 - large
- * Q4 is concerned directly with the minimal media attributes necessary to teach an objective
 - verbal and/or symbolic and/or static simple pictorial
 - verbal and/or symbolic and/or static complex pictorial
 - dynamic pictorial
 - interactive
- * Q5 deals with the memory load required
 - small
 - large

At each decision point, an attempt is made to determine the critical features of an objective which in turn will determine the best media to use in teaching the objective. The termination points refer to three or four media selected for each training objective from the above media list in rank order, or provide additional information or questions to be asked in the selection process (Kribs, Simpson and Mark, 1983, p. 17).

4. Critique of Existing Models

The three media models were evaluated by H. D. Kribs, A. C. Simpson, and L. J. Mark of Instructional Science and Development, Inc. within the context of seven characteristics required for an adequate model: (1) Technique for Professionals, (2) Useful Variable, (3) Media Alternatives, (4) Training System Descriptions, (5) Growth Potential, (6) Data Manipulation and (7) Testing (see Table 1). The characteristics of an adequate media selection model were defined in a study conducted by the Navy's Training and Evaluation Group (Kribs, Simpson and Mark, 1983, p. 22).

With respect to the first characteristic, Kribs, Simpson and Mark decided that the existing models were techniques that assisted professionals in handling media selection with varying degrees of adequacy. In terms of the last characteristic, testing, several of the models were previously tested with objectives from several projects and none of them was considered to be widely applicable.

Table 1. SEVEN CHARACTERISTICS OF AN ADEQUATE MEDIA SELECTION MODEL (Kribs, Simpson and Mark, 1983, p. 23)

CHARACTERISTIC	DESCRIPTION
1) Technique for Professionals	Tool to assist instructional technologists performing a judgmental task that cannot fully proceduralized. Formal process with defined terms and logic based on concepts about the processes of teaching and learning
2) Useful Variables	2 Types: (1) variables that describe a training program as a learning system (i.e. stimulus modes, response modes, learning strategies) and (2) variables that define cost/constraint trade-offs.
3) Media Alternatives	Extensive pool, both traditional and new of instructional media for supporting classroom individualized and on-the-job training/instruction.
4) Training System Descriptions	Descriptions of: (1) broad instructional strategies for general types of tasks, (2) mixes of media for specific tasks, (3) specific design parameters to be put into training
5) Growth Potential	Capability for adding or changing media training learning guidelines, and economic factors applicable in a broad variety of current and emerging situations.
6) Data Manipulation	Emphasis on decision making, with data retrieval/processing as a minor task. Manages computations and mechanics of combining factors through the use of automatic data processing, 2D tables, and simple mathematics
7) Testing	Tested with objectives from several training projects. Adaptable to a variety of training projects.

Each model was found to be limited and inflexible in one or all of the remaining five characteristics (Kribs, Simpson and Mark, 1983, p. 22).

Previous experience with the MIL-T model indicated that it was adequate for grouping objectives into general categories of media requirements, but there were some

problems and limitations. First, the limited media pool kept the selections at a broad, general level. In addition, it seemed difficult to add additional media to the pool since the logic governing the relationships among the instructional characteristics and the media themselves was not explicit (Kribs, Simpson and Mark, 1983, p. 22).

According to the team of evaluators, the application of the TECEP technique proved to be a difficult task. In general, the model was not flexible to user requirements. No technique for adding media or instructional attributes to the IDSS Charts was provided, and use of the alternative approach was difficult and time intensive. The media selections were quite specific, rather than broad and general. The model was not adaptable to variations in the stage of development for proposed training programs (Kribs, Simpson and Mark, 1983, p. 24).

In contrast, the evaluators decided that the TAEG model provided more user flexibility. The format of the media selection matrix made it fairly easy to use because the task categories, task elements, learning guidelines, and media pool were contained in one matrix. The existing media pool was limited, but additional media options could be added (Kribs, Simpson and Mark, 1983, p. 24).

F. CONCLUSION

When evaluating combinations of media, the objective is to choose that combination which can be effectively used to increase a user's learning and comprehension. As Kozma (1991) has indicated, a medium's ability to enhance the learning experience is dependent not only upon the task and the user's learning capabilities, but also upon the ability of the instructional design to fit a medium's capabilities to those required by the user. When

fitting media to the person, consideration must be given to the use of appropriate memory keys. The goal of media selection, therefore, is to minimize the interference in presentations and enable the cognitive processor to process inputs effectively from the perceptual processor to allow for the transfer of as much information as possible from working memory to long-term memory.

This suggests then, that how information is presented will play a large part in decay rates. It is the symbol system that conveys information to the user and as such symbol systems are the essence of media selection. This leads us to the conclusion that even though the content may be the same, the ability to process various media effectively is dependent on the symbol system employed. These associations of symbol systems provide users with various linguistic and iconic codes that are processed and interpreted differently in memory by the individual user (Nugent, 1982, p. 164). Multimedia presentations must, therefore, present information in the most appropriate medium in order to allow the perceptual aspects of learning to support the cognitive aspects and to create reinforcement of the task or subject in such a way as to permit recall of the subject when the material is required.

Research suggests that capabilities of a particular medium, in conjunction with methods that take advantage of these capabilities, interact with and influence the ways learners represent and process information and may result in more or different learning when one medium is compared to another for certain learners and tasks (Kozma, 1991, p. 179).

III. TASK DEFINITION/PRELIMINARY DESIGN

A. INTRODUCTION

The initial research for this thesis was conducted with the intent to design a hypermedia training module using multimedia links for the Navy's 76mm gun. Equipment limitations precluded completion of the project. This chapter defines and discusses multimedia, hypermedia/hypertext, user interface guidelines and the screen design principles that were the underlying factors in the design of the training module for the Navy's 76mm gun which is located onboard the FFG-7 class frigates. These topics are discussed to provide follow on users/designers with the baseline that was established in this initial design effort. In addition, a definition of the selected task is provided. Preliminary screen designs and an overall system structure are provided. Additionally, Appendix C lists the video tapes that were made available for this project by the Gunnersmate class A school in San Diego, California.

Explanations for the use of certain types of media for a given presentation as related to findings in Chapter II are provided. The chapter concludes with a brief description of the software and hardware used in the initial design effort.

B. DEFINITION OF MULTIMEDIA

Olson (1974) suggests that multimedia is an instructional and informational model that permits the presentation of a wide range of knowledge and information in a variety of interactive media. (Olson, 1974, p. 420) (Blattner and Dunnenberg, 1992, p. 233) A

multimedia system has an overwhelming advantage over classroom teaching or lectures in its ability to support a wide range of instructional models. In addition, multimedia technology provides the user control over his/her learning and further provides the ability to progress in any number of possible directions. (Olson, 1974, p. 420) These benefits allow users of varying mental abilities and learning skills to use the same material and unlike classroom study or lectures allows students to backtrack, when necessary or desirable, without affecting other students. Hapeshi and Jones (1992) suggest that giving control to the student increases motivation and will therefore increase learning (Hapeshi and Jones, 1992, p. 80).

While many researchers have concluded that multimedia presentations have the ability to increase motivation it must also be argued that regardless of student motivation media must be selected and ordered so as to present the chosen topic or task in a manner that will increase retention and maintain a learners motivation throughout the module (Hapeshi and Jones, 1992, pp. 80-81).

C. DEFINITION OF HYPERTEXT

The traditional definition of the term "hypertext" implies that it is a system for dealing with plain text. Since many of the current systems today also include the capability of working with audio, video, and other media types we can now change the term "hypertext" to "hypermedia". Hypermedia follows the same guidelines as hypertext. However, instead of just stressing the use of solely textual data we now stress the multimedia aspects.

Hypermedia is a technique for supporting multimedia interfaces since it is based on the interlinking of nodes that contain different media. Typical media in a hypermedia document include text, graphics, audio, and full motion video.

Graphics can be either scanned images or object-oriented pictures constructed by some computer graphics system. It can be used as an illustration or can be more actively involved with the hypertext aspects of the hypermedia system by also including anchors for the hypertext links (Nielsen, 1990, p. 5).

Audio and motion video are also common data types in a hypermedia document. According to Jakob Nielsen, a recognized expert on hypertext and hypermedia, one of the difficulties with representing video and sound in the document is the question of how to name links. The most common solution has been to use plain text as the anchor leading to the play of a piece of audio or video.

Many people believe that a hypermedia document is no more than a database. However, hypermedia is different from databases from the user's perspective. A database has an extremely regular structure defined by a high-level data definition language. All of the data follow this single structure. A hypermedia information base has no central definition and no regular structure. Each hypermedia node is very extensive, with a lot of information. Some of the nodes have added links to other nodes. In general, the structure of a hypermedia network is defined as a union of each of the individual nodes and links. Each link is put in because it makes sense in terms of the contents of the two nodes it connects and not because of some global decision about the structure (Nielsen, 1990, p. 8). This makes hypermedia very flexible. However, one must note that even though a

system may be multimedia based, it need not be a hypermedia system. The mixture of text, graphics, audio and video is not enough in itself make a document a hypermedia document. Many multimedia systems are based mostly on displaying various forms of media to a passive user who does not get to control the navigation. Only when users interactively take control of a set of dynamic links among units of information can we define the system a hypermedia system.

D. USER INTERFACE GUIDELINES

Learning anything new is a challenge. Although challenge is usually satisfying, when it comes to learning many people experience anxiety, frustration, and disappointment. Much of the difficulty flows directly from the poor design of the user interface (Shneiderman, 1992, p. 441).

Creating user interfaces is a complex and highly creative process that blends intuition, experience, and careful consideration of numerous technical issues. In designing the user interface, a vital foundation for interactive systems is an understanding of the cognitive and perceptual abilities of the users. However, there are some common, underlying principles of design that are applicable in most interactive systems: (Shneiderman, 1992, p. 72)

- * *Strive for consistency.* This principle is the most frequently violated one, and yet is the easiest one to repair and avoid. Consistent sequences of actions should be required in similar situations; identical terminology should be used in prompts, menus, and help screens; and consistent commands should be employed throughout. Exceptions should be comprehensible and limited in number.
- * *Enable frequent users to use shortcuts.* As the frequency of use increases, so do the user's desires to reduce the number of interactions and to increase the pace of interaction.

- * *Offer informative feedback.* For every operator action, there should be some system feedback.
- * *Design dialogs to yield closure.* Sequences of actions should be organized into groups with a beginning, middle, and end.
- * *Permit easy reversal of actions.* As much as possible, actions should be reversible. The units of reversibility may be a single action, a data entry, or a complete group of actions.
- * *Reduce short-term memory load.* The limitation of human information processing in short-term memory requires that displays be kept simple, multiple page displays be consolidated, window-motion frequency be reduced, and sufficient training time be allotted for sequences of actions.

According to Shneiderman, when using a hypertext/hypermedia user interface design, the first step is to choose projects that adhere to the Golden Rules of Hypertext (Shneiderman, 1992, p. 410).

- * There is a large body of information organized into numerous fragments.
- * The fragments relate to one another.
- * The user needs only a small fraction of the fragments at any time.

The dual dangers to be avoided in design of a hypermedia system are that hypermedia may be inappropriate for some projects and that the design of the hypermedia may be poor. Poor design of hypertext is the more common problem: Too many links are overwhelming, too many long articles makes reading dull and noninteractive, long chains of links to reach required information can be disorienting, and inadequate tables of contents make it difficult for users to determine what is contained in the hypertext. Just because a text has been broken down into fragments and linked does not ensure that it will be effective or attractive. Successful hypertext/hypermedia depends on good design of the contents (Shneiderman, 1992, p. 411).

Creating documents for a hypermedia database introduces some additional considerations beyond the general guiding principles. According to Shneiderman, these include (Shneiderman, 1992, pp. 415-416):

- * *Know the user and their tasks:* Users are a vital source of ideas and feedback; if possible, use them throughout the development process to test the design.
- * *Ensure that meaningful structure comes first:* Build the project around the structuring and presentation of information, not around the technology.
- * *Respect chunking:* The information to be presented needs to be organized into small "chunks" that deal with one topic, theme, or idea. Each chunk should represent a node or document in the database.
- * *Show interrelationships:* Each document should contain links to other documents. The more links contained in the documents, the richer the connectivity of the hypertext. Too few links means that the medium of hypertext may be inappropriate; too many links can overwhelm and distract the user.
- * *Ensure simplicity in traversal:* Design the link structure so that navigation is simple, intuitive, and consistent throughout the system. Use simple, comprehensible structures that the users can use as a cognitive map. In addition, make recovery simple!
- * *Require low cognitive load:* Minimize the burden on the user's short-term memory. The goal is to enable users to concentrate on their tasks and on the contents while the computer vanishes.

E. SCREEN DESIGN PRINCIPLES

One of the most important factors in presentation design is to structure the presentation to enable the user to focus on the critical aspects of the presentation. This may be accomplished in numerous ways: highlighting what is important, short concise sentences, restricting the use of styles so as not to distract the user and most importantly, keep it as simple as possible. (Chabay and Sherwood, 1992, 158-161) Other important factors that must be addressed are user frustration, feedback (both instructional and system operation), allowing users to progress at their own pace by allowing choice of

activity and allowing the user the opportunity to exit from various points in the presentation. To accomplish these goals the designer must limit the user's ability to jump at will, while allowing the user freedom of movement through the presentation to maintain motivation and attention. (Chabay and Sherwood, 1992, pp. 173-182)

F. TASK DEFINITION

The largest class of ship in the U.S. Navy is the Oliver Hazzard Perry class guided missile frigate (FFG-7 class). These ships were designed with a multi-mission capability and to operate with a minimum crew size. These minimum manning levels place extreme pressure on senior personnel. They must ensure junior personnel are not only well trained in their own rate specialty but, they must also be capable of handling jobs that are outside their rate specialty with little or no supervision.

One of the most dangerous and complicated systems aboard any ship is the weapons system. It is also a system that unfortunately, due to the high cost of operation, gets only limited use in a peaceful benign environment. If developed, this module would allow junior and senior personnel to maintain the necessary familiarization with the system during non-firing periods, as well as allowing for the indoctrination of new personnel without firing the weapon.

The Specific Planned Maintenance System (PMS) check chosen is the R-1 prefire check (firing zone cutout portion) for the 76mm gunmount (see Appendix A). The R-1 PMS check chosen requires users to possess mechanical skills, the ability to correctly read and interpolate gauges and measuring tools, understand system interrelationships, follow basic troubleshooting procedures and to read understand and follow safety procedures. A

system of this nature is an excellent candidate for the development of a multimedia training presentation, the stability of text, combined with the ability of full motion video to demonstrate mechanical movement allows users of differing skill levels to develop the requisite level of proficiency while allowing all users to process information at their own pace. Figure 3 is a graphical description of the entire PMS procedure. The highlighted section is the firing zone cutout portion. This was the portion that was selected for hypermedia, multimedia development. Figure 4 is a graphical representation of the steps required for the firing zone cutout section of the check.

The R-1 is a mandatory check that is required before the gun may be fired. The purpose of the check is twofold: 1) it provides the commanding officer with an assessment of the readiness of the weapon system and 2) it assures him that all of the safety features are operating properly.

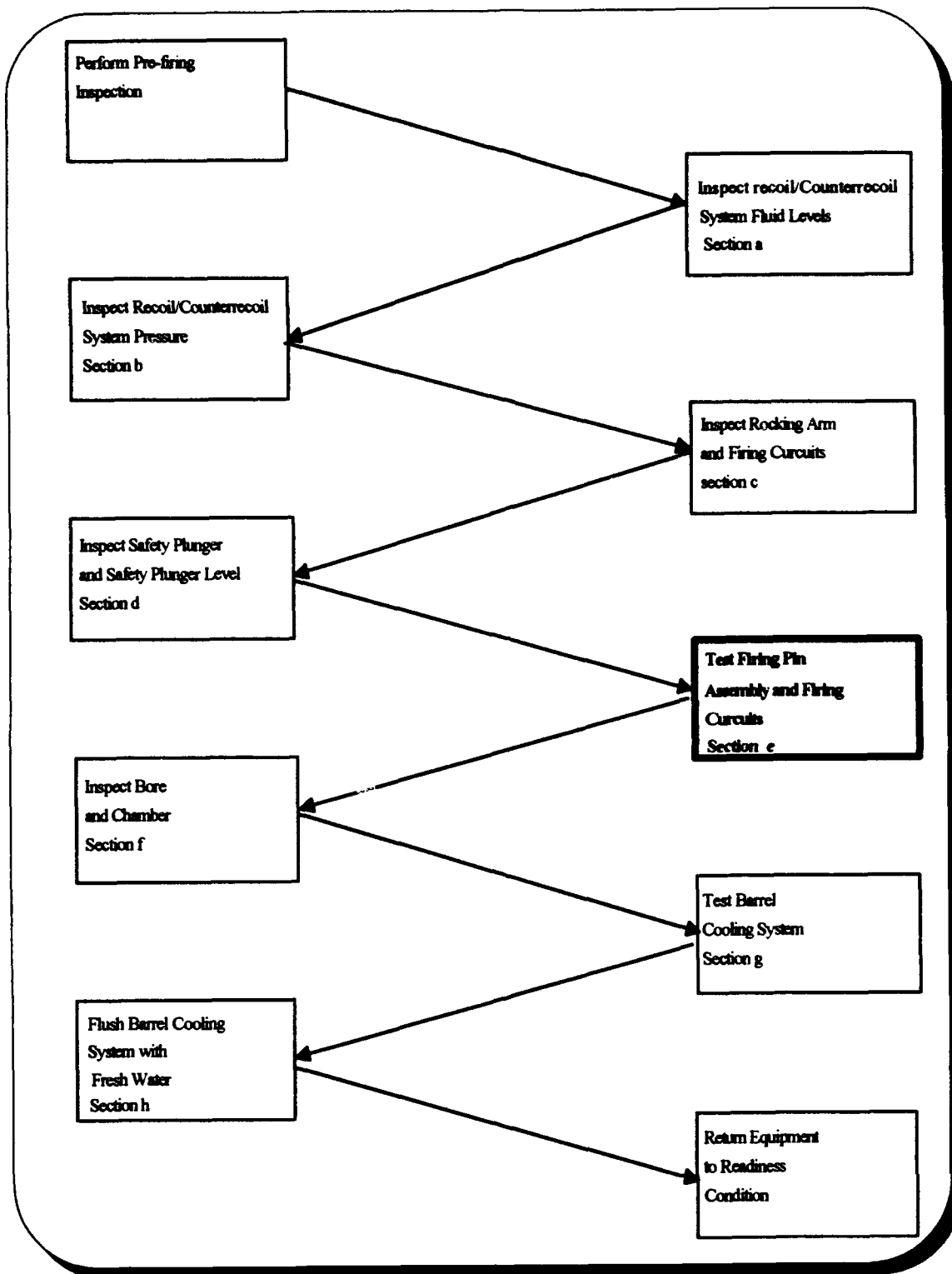


Figure 3. R-1 PMS check procedures.

An indication of the importance of this portion of the check is the requirement that the weapons officer be present and verify the results. Additionally, the check requires close coordination between combat information center and bridge personnel, and requires the commanding officer's permission. The check is conducted, ideally, by one gunnersmate guns third class (GMG3, E-4) and two gunnersmate guns seaman (GMGSN, E-3). As

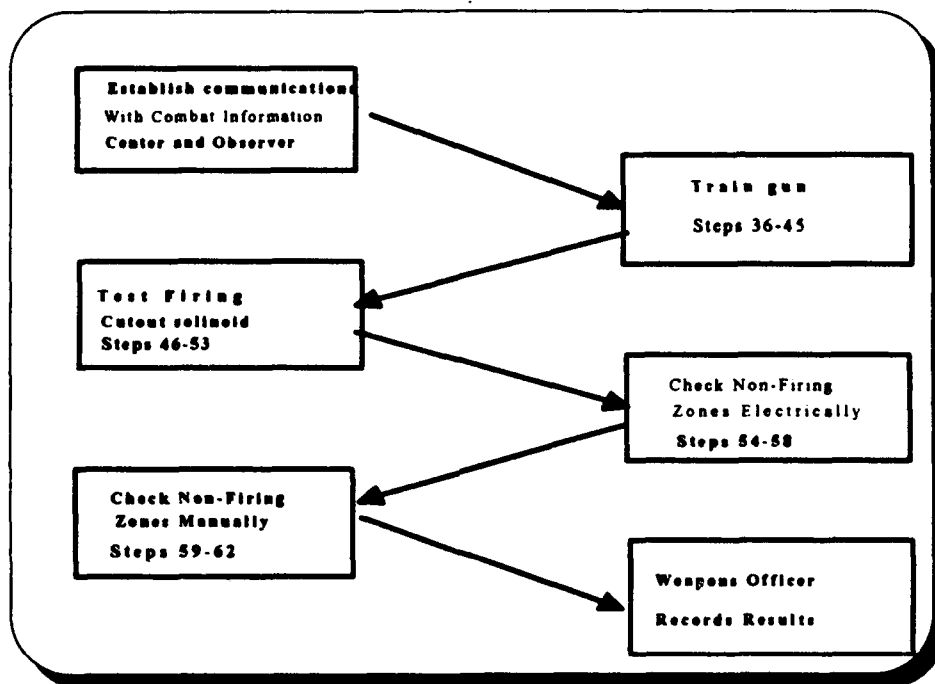


Figure 4. Firing zone cutout portion of R-1 PMS check

discussed earlier, manning levels may require more junior personnel complete the check. However, any personnel completing any preventive maintenance check onboard a naval vessel must be fully qualified to perform the check. This is a Navy wide standard. This module, when developed, would aid personnel in gaining their qualifications by providing them simulated, interactive instruction.

This module will provide an overview of the system and could be expanded to provide an aid for trouble shooting.

G. SCREEN PRESENTATIONS

Due to hardware and software limitations (discussed in Chapter IV) the development of the training module for firing cutout portion of the R-1 PMS check was not completed.

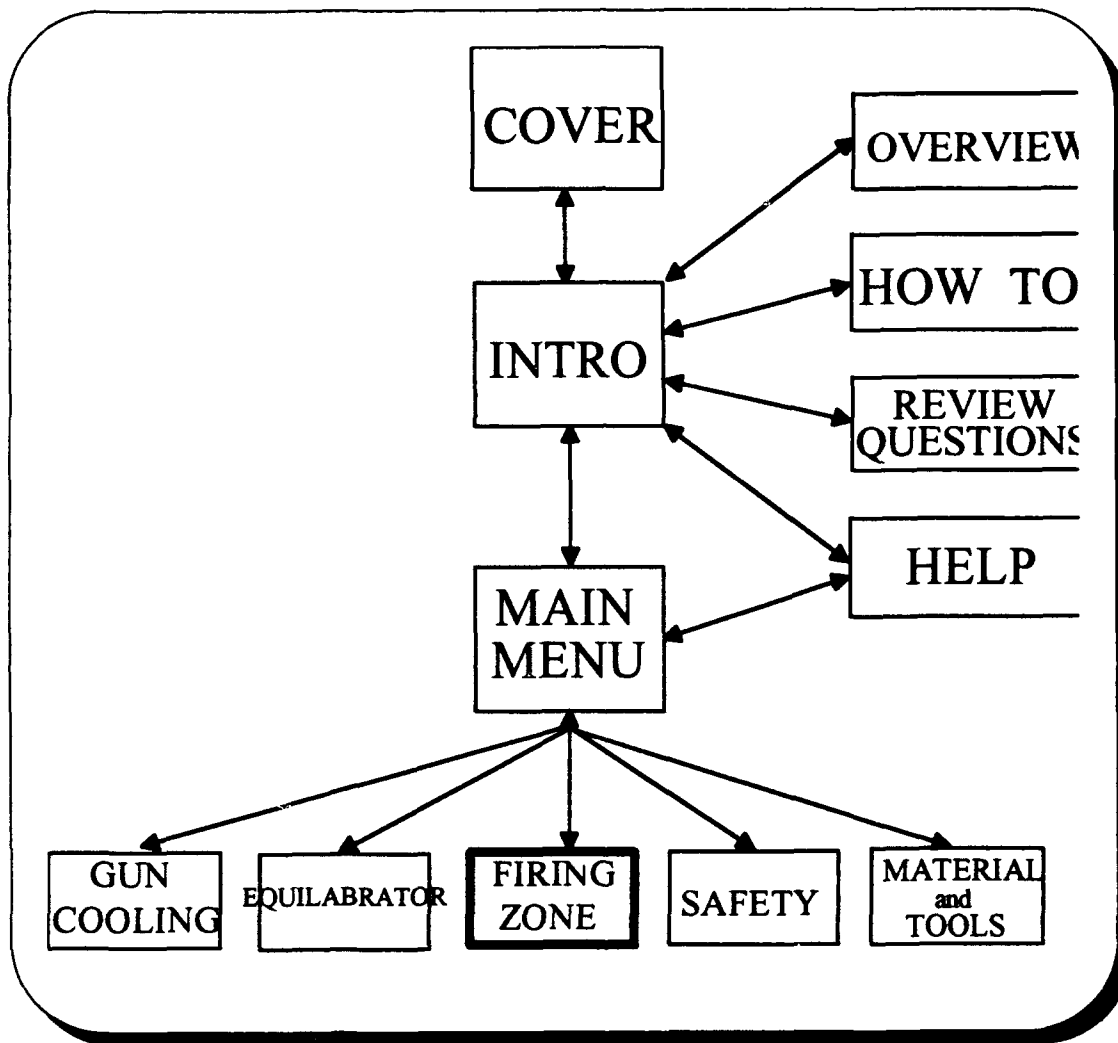


Figure 5. Presentation overview.

The following sections discuss screen layouts and system design features developed in preparation of system. Figure 5 provides a graphical overview of the presentation showing screen connections.

For ease of navigation throughout the document screens are designed to be used with a mouse in a point and click format. In addition, continue and back buttons are used to allow the user to proceed or backtrack as necessary. Help screens provide assistance at various points and are used to answer questions on screen presentations. The choice of media (text, text/pictures, or full motion video) to be used for segments of the presentation was based on research conducted in Chapter II to take advantage of the perceptual and cognitive human processing skills.

For ease of future expansion the PMS check was broken into five segments: (1) gun cooling, (2) equilibrator, (3) firing zone cutout, (4) safety precautions, (5) materials and tools (see Figure 6).

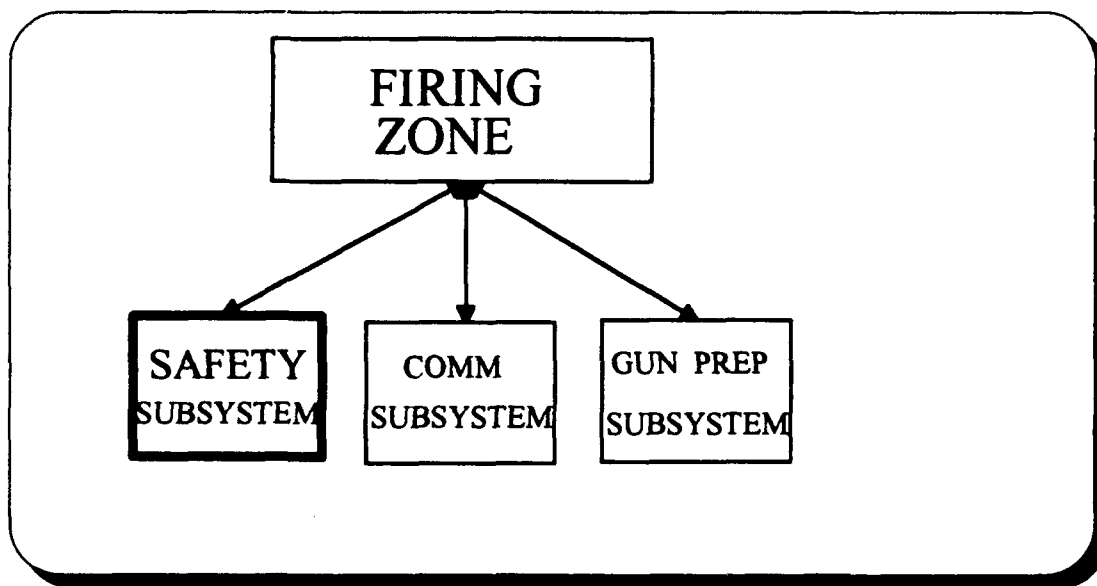


Figure 6. Subsystem connections.

For clarity and ease of development the firing zone cutout portion of the presentation was divided into three subsystems: (1) the safety subsection, (2) the communications subsection and (3) the gun preparation subsystem .

Each subsystem contains: (1) learning objectives to enable the user to focus on those portions of the check believed to be most important, (2) test questions to test comprehension of material presented, (3) presentation reviews to allow users to review material prior to answering questions and (4) help screens. (see Figure 7)

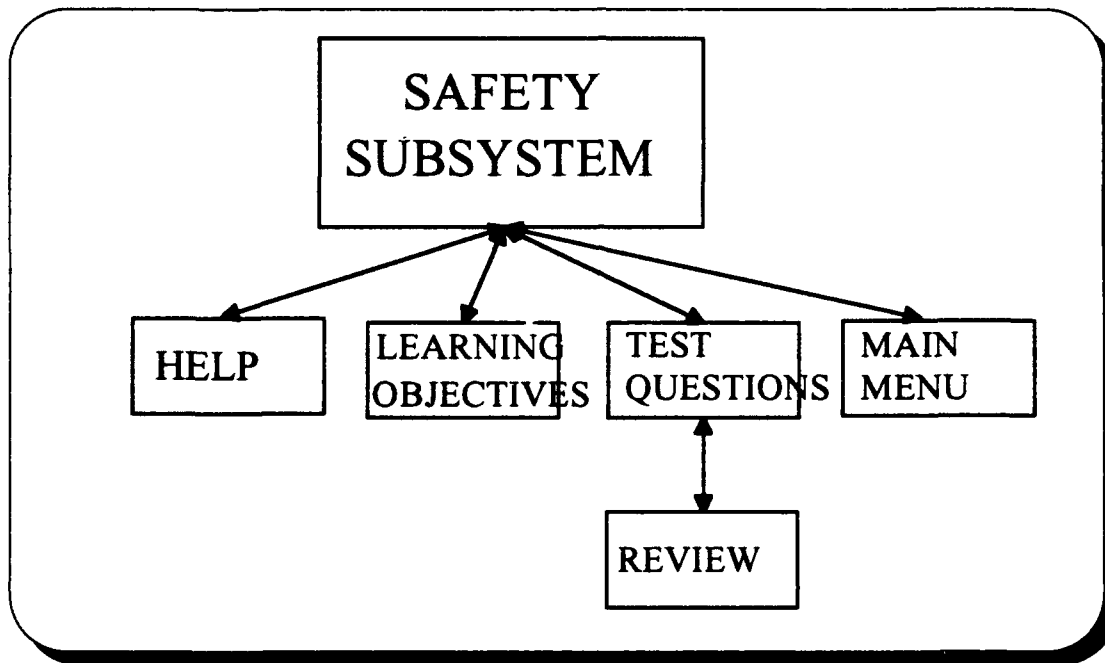


Figure 7. Safety subsystem connections.

Upon completion of each subsystem, the user is required to answer five multiple choice questions correctly before being allowed to proceed to the next subsection. Each wrong answer will automatically launch into a full motion video or text explanation of the correct answer. At the conclusion of the presentation the user is returned to the questions so he/she may choose the correct answer. All questions are based upon the learning objectives. After correctly answering all questions, users are then asked if they would like to proceed to the next subsystem.

The amount of information presented on each screen is limited to stay within the limits of working memory and to maintain consistency with the perceptual and cognitive aspects of learning and comprehension as discussed in Chapter II. Appendix B provides a complete set of screen layouts developed for this module.

1. Screen Presentations: Text

Learning objectives, test questions and menu screens are presented with text. The stability of text allows readers of differing skill levels to process the information at their own pace. Slower readers and users with less domain knowledge are therefore allowed to focus on each item separately and remain on the screen until they feel comfortable enough with the material presented.

The number of pieces of information are limited to five per screen to increase the opportunity for users to transfer the information from working memory to long-term memory.

Text is also used so relevant portions of the safety manual can be reviewed at the user's pace. As addressed, the testing and learning objectives portion should also be in text to provide the required stability and allow users to comprehend the questions carefully before answering.

2. Screen Presentations: Text/Pictures

The materials and tools portions of the presentation should consist of text/picture combinations, as they may be used to show pictures of the tools and materials with written descriptions from technical and supply manuals. Text reinforced with stills

provides an effective presentation that not only allows users to read the description of the tool or required material, but also to gain proficiency and recognition skills.

3. Screen Presentations: Full Motion Video

Help screens should be designed with full motion video presentations to better present system operation and interrelationships. Full motion video is much more effective than text in demonstrating how a piece of equipment actually operates. It also provides a great deal of system interrelational information (cause and effect relationships between systems) that could not be provided by text or text and pictures.

All screens developed during initial development efforts are displayed in Appendix B. The choice of media for each presentation was based upon the perceptual and cognitive requirements of the task using a combination of the media selection models discussed in Chapter II.

H. SYSTEM COMPONENTS

The following is a listing and brief description of the hardware and software used in the initial development attempts for the firing zone cutout portion of the R-1 PMS Check training module.

1. System Hardware

The following hardware components were used in initial development attempt:

a. SUN Desktop SPARCstation 10

The SPARCstation 10 is a high performance workstation designed to be used alone or as part of a network. The SPARCstation 10 has an Attachment Unit

Interface (AUI)/Audio port for connecting the Sun SpeakerBox (Sun Microsystems, 1992).

b. *Parallax XVIDEO Card*

The Parallax XVIDEO Card integrates photo-realistic imaging, hardware image compression, and real-time 24-bit video digitizing. XVIDEO makes it possible to squeeze, clip and place live video in any location on the screen. Furthermore, motion video can be stored and played back from a hard disk or shared over a network. Other capabilities include (Parallax Graphics, 1991):

- * *Real-time frame capturing from a live video input.* The images can be edited and used as needed.
- * *Simultaneous video inputs.* A Video Input Output (VIO) or Red Green Blue (RGB) card may be added to enable XVIDEO to display two live video inputs simultaneously in separate windows.
- * *Live video output from a window.* If using a VIO or RGB card, XVIDEO provides the capability to output images from a window in real-time to film recorders, VCRs, video post-processors, or multimedia equipment.
- * *24-bit Video Plus Flexible Overlays.* Live and still video, with graphics and text, are integrated to provide special effects or image enhancements.

XVIDEO's accelerated graphics performance improves application speeds. This enables the standard 8-bit SUN software to run as if it was running with a dedicated 8-bit buffer.

c. Microphone/Speaker

The Speaker provides 16-bit audio and may be connected directly to the AUI/Audio port or through an AUI/Audio adapter cable. The speaker system specifications are (Sun Microsystems, 1992):

- * Input via the external microphone with sensitivity to pick up human voice in the 50-70dB range @ 1 meter with a frequency response of 100 Hz to 5 KHz, 4 dB minimum.
- * Audio output via a loudspeaker with a minimum output of 85 dB @ 1 meter over a 200 Hz to 10 KHz/5dB range.
- * The microphone is omni-directional and has a frequency response of 50 Hz to 8 KHz, 3dB minimum. The output level is -29dB to 4 dB.

d. Sony LDP-1550 Videodisc Player

The Sony LDP-1550 Videodisc Player may be controlled using the control buttons on the player or through a microcomputer. It uses both constant angular velocity (CAV) discs and constant linear velocity (CLV) discs. A CAV disc must be used if fast forward or reverse playback is required .

2. System Software

The following is a discussion of the various software tools used during development efforts.

a. UNIX Operating System/OpenWindows

The OpenWindows windowing system was used working under a UNIX based operating system for system development (Sun Microsystems, 1990).

b. MAestro Authoring System

The MAestro Authoring System enables integration of multiple media sources into one document. MAestro was developed by a research project conducted at

Stanford University with the assistance of Sun Microsystems and was designed to accommodate various authorship styles and applications. MAestro was designed with the intention of allowing students and faculty to quickly and easily design and implement multimedia presentations.

Media editors are employed by MAestro to integrate various forms of data. These editors store pointers to the desired materials, not clip itself. The following is a brief description of the various media editors (Drapeau, 1992, pp. 1-1-7-22):

(1) *Portmanager*. Controls the sequencing of all applications and assigns port numbers to port names.

(2) *CdEdit*. This editor allows saving segments from a compact disc. The editor stores start and stop points of the chosen segments for later playback.

(3) *VideoEdit*. This application was designed to provide editing capabilities for video discs. Any number of video frames may be saved from video applications.

(4) *QuoteMaker*. This editor allows the author to choose quotes from various text files. It allows for the saving of single quotes or browsing through text files and compiling lists of quotes for display. Any number of pointers may be saved from as small as a single character to a complete chapter of text.

(5) *Searcher*. This feature allows the author to save a list of text searches. It then allows for the retrieval of desired text. It also provides the capability to resume a search at another time, starting where the previous search ended.

(6) *VcrEdit*. Enables an author to search VHS tapes for desired data. The editor saves start and stop points in the same manner as VideoEdit. However, unlike VideoEdit, VcrEdit does not possess a link to a video display. The application VideoFrame is required to view clips.

(7) *VideoFrame*. A display application used in conjunction with VcrEdit. It enables the author to view video clips when using VcrEdit.

(8) *ShellEdit*. Allows for the use of UNIX applications that do not use MAEStro protocols.

(9) *Digital Tape Recorder (DTREdit)*. This application allows for the storage and playback of saved audio clips.

(10) *Timeline Editor*. This application integrates all clips previously saved from various editors. It enables the author to place and edit these clips on a timeline. The author saves clips using the media editors and then places these clips on the timeline in the desired order. Additionally, the timeline editor automatically opens editors that have been placed on the timeline when called. The timeline editor is also used when creating a hypertext/hypermedia document.

c. FrameMaker

FrameMaker is a sophisticated multi-platform publishing software application that may be used to create interactive, multimedia educational documents. In addition, Framemaker's multi-platform capability permits document sharing and allows for easy importing of text and graphics from other application software. Framemaker also

provides the flexibility to create hypermedia documents as well as the capability to call external programs for use within documents.

IV. CONCLUSIONS/RECOMMENDATIONS/PROBLEMS ENCOUNTERED

A. CONCLUSIONS

Advances in computer technology have led to the development of a myriad of multimedia presentations. To support learning, recent research makes it quite apparent that technology will not be the limiting factor in the future development of multimedia learning presentations. The development of any presentation, therefore, must look beyond available technical capabilities, and focus on the abilities of the user to perceptually and cognitively process the presentation. The designers objective, then, is to choose presentations of media that are most appropriate for a given situation. While there is a large body of often conflicting media selection information, most of which is based upon psychological studies and learning theory, research does suggest that the selection of the appropriate medium, when fitted to a specific learner and task, does affect and influence the ways in which people represent and process information (Kozma, 1991, p. 182) (Salomon 1974,1979).

The Navy Personnel Research and Development Center in a 1988 report entitled Guidelines for the Development of Military Training Decision Aids, examined 23 existing decision aids and media selection methods. The report cited the fact that current specifications for choosing the correct media for a presentation must often be made with

little specific guidance and offered the following conclusions and recommendations for improving the current situation:

- * Most existing training decision aids have not been found to be effective in aiding personnel to select training situations/levels or media.
- * None of the reviewed aids satisfy all of the required attributes identified in this report. However, many existing training decision aids contain desirable criteria that could be incorporated into more effective aids that would be suitable for military requirements.
- * Methods for designing more effective military training decision aids that incorporate desirable selection criteria are needed.
- * Develop training decision aids for specific military applications.
- * Develop training decision aids for specific types of tasks.
- * Consider a combination of training presentation methods and media for teaching each task.

While this is not a complete listing of the reports conclusions and recommendations, as the study did not address hypermedia/multimedia directly, it does support the development of the 76mm firing zone cutout module addressed in this thesis.

Symbol systems carry the content or message of the media and the same content can be carried by different media. Associations of symbol systems provide users with various linguistic and iconic codes that are processed and interpreted differently in memory by the individual user (Nugent, 1982, p. 164). This leads to the conclusion that even though the content may be the same, the user's ability to process various media effectively is dependent upon the symbol system employed. Since learners do not possess equal processing abilities, it is the task of the designer to choose a presentation method that compliments a users abilities. The way in which media influence the human processing

capacity, therefore, should be evaluated and media chosen so as to complement the capabilities of the user.

Media selection has been an extremely problematic task for both industry and the Department of Defense (DOD). A number of structured media selection models have been developed in an attempt to standardize the media selection process. However, most of these models have proven to be of limited value. This is due to several factors. Some, especially some of the existing military models, are too broad or general and of little value for more advanced or specific training programs. Additionally, some models tend to be overly theoretical, ignoring important practical considerations such as availability of equipment and almost all are too rigid; an inability to adapt and update to new technologies and changing needs/requirements.

A variety of factors contributes to the difficulty and complexity of the media selection task, especially for the military. First, the nature of military jobs poses intrinsic difficulty in selecting an optimal media mix. Frequently, job performance involves a combination of procedural, perceptual, cognitive, motor, and knowledge components, including decision making, which must be integrated. Thus, it is often difficult to associate one specific medium with the learning task given a variety of attributes required of a medium in order to best learn to perform the task.

The importance of choosing the correct media presentation for a task is supported by research that suggests that capabilities of a particular medium, in conjunction with methods that take advantage of these capabilities, interact with and influence the ways learners represent and process information and may result in more or different learning

when one medium is compared to another for certain learners and tasks (Kozma, 1991, p. 179).

The most common media encountered today in a learning environment is text. A distinctive property of text is its stability (i.e., permanently printed orthographic symbols that allow for review or regression anytime). Stability has important implications for how learners process information. Specifically, the stability of text aids comprehension by allowing the user to construct a meaning of the text (Kozma, 1991, p. 183).

Most studies support the premise that the use of pictures with text increases recall, particularly for poor readers. Study results suggest that people with low mechanical ability have difficulty forming mental models from text alone and the use of diagrams helps them in constructing a representation. Where as, people with high mechanical ability seem to construct this model from prior knowledge and information. Pictures illustrate information central to the text, when they represent new content that is important to the overall message, or when they depict structural relationships mentioned in the text (Kozma, 1991, p. 185).

A designer must therefore, consider these capabilities when designing any presentation. Media should be chosen so that it complements user's skills and deficiencies. Authors can use the stability of text and pictures to design structures that support and facilitate learning (Kozma, 1991, p. 188). Pictures alone can provide a wealth of information, but to be an effective tool pictures must be used in combination with other media such as text or audio to provide the focus required for efficient learning (Nugent, 1982, p. 165).

As with text and pictures, motion video can employ pictures, diagrams, and other symbols, but, in motion video, these symbols are transient and are able to depict motion. Because linguistic and pictorial symbols are transient, viewers may perceptually process this information in a different manner than the serial back-and-forth processing of text and pictures (Kozma, 1991, p. 189).

Since motion video has the ability to use both audio and video simultaneously, one question that arises is what is the effect of using these media types, both independently and together, to influence comprehension and learning? Conrad (1964) suggests that acoustic presentations cause interference in working memory and as such, learners may become confused. Whereas Long-Term memory may be more sensitive to interference from written phrases that may have confusing or contradictory meanings.

The proliferation of new and better computing technology has allowed for the transition from a single teacher-multiple student setting to one of one-on-one, human, computer interactions in a multimedia/hypermedia environment. Unfortunately, this was not the case for the development of the 76mm training presentation planned for this thesis. Hardware and software problems caused considerable frustration. The following segment is a synopsis of problems encountered in the development of a training presentation for the 76mm gun.

B. PROBLEMS ENCOUNTERED

Hardware and software problems caused considerable frustration in initial system development efforts.

- * Two types of laser discs are available, CAV and CLV. Due to frame numbering and sequencing on the discs, only CAV discs can be controlled by a computer. Prices of the discs are relatively equal. However, play time is approximately twice as long on CAV discs because both sides of the disc are used. As such, any module design must carefully consider available off-the-shelf or military discs. It is also unreasonable to expect that discs will receive the required level of care in a shipboard environment.
- * The SUN workstation documentation does not cover computer connections to the external microphone, Video disk player, CD player, and other peripherals required for the development of a multimedia presentation thoroughly. Fortunately, the SUN system documentation addresses most connections required to connect peripherals, but covers little in the way of troubleshooting problems that may be encountered during system set-up.
- * MAEstro is still in the developmental phase. We were required to make coding changes to get the applications to operate on the Sparc 10. Also, documentation is weak at best. Not all of the editors are addressed in detail in the documentation. Further, obtaining assistance is nearly impossible. The main designer of the authoring system has since left his original position at Stanford University. Therefore, it is very difficult to contact anyone connected with the system.
- * Not all of the editors work as advertised. VideoEdit will not work with the Sony 1550 laser disc player even though this player is a selection on the VideoEdit menu. Instead, VCRedit must be used to edit laser disc clips. This is ineffective due to the fact that VCRedit does not provide a display screen for viewing of saved video clips. However, VideoEdit will not be available with follow-on releases of the MAEstro authoring tool.
- * There is no supporting documentation for the VideoFrame editor, and due to a coding problem we are unable to set our player as the default player.
- * The tool in MAEstro called digital tape recorder editor (DTREdit) is supposed to allow for recording of audio files, but it does not work correctly and there is no documentation to support the editor. Therefore, the audiotool provided with OpenWindows must be used to save audio clips for import into a multimedia document.
- * Portmanager is designed to initialize automatically upon start up. Unfortunately, this is not always the case. Additionally, we found Portmanager lacking in robustness and needed to be called before applications were started.
- * Our SUN workstation does not work effectively with the speaker. We were unable to get sound due to an impedance mismatch. This required a special box to be built to match impedance levels. This caused many months of delay.

- * Hardware unavailable. The videos necessary to create the presentation were made available by the Gunnersmate class A school in San Diego, unfortunately, we were unable to use the tapes as a computer controllable VCR was not available.

C. RECOMMENDATIONS FOR FUTURE DEVELOPMENT

With the Navy's renewed commitment to move toward a smaller more technically qualified force, and continued budget reductions for personnel, operations and training the development of multimedia training modules is a technically viable and realistic alternative for maintaining operational readiness. The information provided in this thesis may be used as a foundation for the development and implementation of various instructional presentations related to shipboard operations and maintenance.

APPENDIX A

PMS PROCEDURE MRC 710-7111-R-1

NOTE 1: Perform this MRC to determine mount readiness for firing. The PHM-1 Class ships shall perform this MRC in port prior to getting underway for a firing exercise, except for step 1.f. which shall be performed when underway just prior to a firing exercise.

Preliminary

- a. Perform MRC R-6 prior to performing this MRC.
- b. Ensure gun is in battery.
- c. Ensure muzzle cap and forward ejector chute covers are removed.

1. Perform Prefiring Inspections.

NOTE 2: An officer shall witness the inspection of recoil/counterrecoil system fluid level.

- a. Inspect recoil/counterrecoil system fluid level (fig 1):
 - (1) Verify gage rod indicator is between the maximum and minimum indicator marks on gage tube.
 - (2) If fluid level is incorrect, refer to MRC U-2 and perform steps 1.b.(1) through 1.b.(12) to fill or drain.

NOTE 3: An officer shall witness the inspection of recoil/counterrecoil system pressure.

NOTE 4: Recoil/counterrecoil system fluid level must be correct prior to inspecting recoil/counterrecoil system pressure.

- b. Inspect recoil/counterrecoil system pressure (fig 1):
 - (1) Ensure valve B is closed using nitrogen valve adapter.
 - (2) Slowly open valve A using nitrogen valve adapter.
 - (3) Pressure gauge should indicate 70 to 74 kg/cm². If pressure is incorrect, refer to MRC U-2 and perform steps 2.b.(1) through 2.b.(14) to replenish.
 - (4) Close valve A using nitrogen valve adapter.
 - (5) Open valve B using nitrogen valve adapter to bleed pressure from gage. Close valve B.
- c. Inspect rocking arm and starwheels.
 - (1) Verify integrity of nose clamp bushings on both rocking arms. If bushings are loose or have fallen out, replace nose clamp.
 - (2) Verify upper and lower starwheels are resting against stop levers before proceeding.

- d. Inspect safety plunger and safety plunger lever:
- (1) Verify safety plunger bushing is lockwired (fig 2).
 - (2) Using feeler gage stock, verify 1.0-mm minimum clearance between safety plunger lever and safety plunger bushing.
 - (3) Measure safety plunger bushing:
 - (a) Using steel rule, measure from top surface of safety plunger bushing to top of surface of breechblock (fig 2).
 - (b) Verify this dimension does not exceed 17 mm.
 - (c) Inspect and replace defective components involved. If safety plunger bushing exceeds this dimension.
 - (d) Verify integrity of safety plunger lever and trigger springs. Replace if broken or if springs fail to return components to locked position.
- e. Test firing pin assembly and firing circuits:
- (1) Disengage train and elevation securing mechanisms.
 - (2) Place gun at hooks position:
 - (a) Set circuit breakers CB1 and CB2 to 1 (on).
 - (b) Press HYDRAULIC UNIT ON pushbutton.
 - (c) Set cold recoil jacks control valve to RECOILED to move recoiling mass to maximum recoil position.
 - (d) Set cold recoil jacks control valve to RUN-OUT to allow cold recoil jacks to fully retract and allow recoiling mass to return to hooks position.
 - (e) Press HYDRAULIC UNIT OFF pushbutton.

WARNING: Injury to personnel or damage to equipment may result if accumulator pressure is not dumped to tank. Allow accumulator to finish dumping on its own before proceeding.

- (3) Allow the accumulator to completely dump on its own. Dump any residual pressure by pressing any holding REVOLVING MAGAZINE pushbutton or holding cold recoil jacks handle to the RECOILED position until pressure has been completely dumped.
- (4) Insert wax into primer slot of 2 rammable dummy rounds.
- (5) Load 2 rammable dummy rounds into outer row of revolving feed magazine.
- (6) Press HYDRAULIC UNIT ON pushbutton to start hydraulic power unit.

WARNING: Ensure personnel are clear of gun loading equipment before and while operating gun loading equipment.

- (7) Press REVOLVING MAGAZINE pushbutton and verify operation of revolving magazine and screw feeder:
 - (a) Dummy rounds move smoothly from outer circle to inner circle of revolving magazine.
 - (b) Dummy rounds move smoothly from inner circle of magazine to last stations of screw feeder.

- (8) Release REVOLVING MAGAZINE pushbutton.
- (9) Press MOUNT LOADING pushbutton and verify operation of rocking arms and loader drum.
- (10) Release MOUNT LOADING pushbutton.
- (11) Using screwdrivers, release empty case consent.

WARNING: Stand clear of rocking arms and gun barrel when indexing 2HP1 to ram a round.

NOTE 5: If fast ram interlock is not installed, omit steps 1.e.(12), 1.e.(14), 1.e.(15), and 1.e.(19).

- (12) Actuate the Fast Ram Interlock Bypass switch. Verify the fast ram interlock can be withdrawn and remade at the hooks position and the empty case consent mode.
- (13) Use T-handle assembly in 2HP1 to manually cycle rocking arms once to ram dummy round (if fast ram interlock is not installed).
- (14) Verify the round indexed onto tray and fast ram interlock is holding the gun (out of battery) at hooks position.
- (15) Actuate the fast ram interlock switch 2S5. Interlock should release gun into battery and ram the round.
- (16) Verify ROUND IN BARREL lamp is lit and MISFIRE lamp is not lit.
- (17) Press HYDRAULIC UNIT OFF pushbutton.

WARNING: Injury to personnel or damage to equipment may result if accumulator pressure is not dumped into tank. Allow accumulator to finish dumping on its own before proceeding.

- (18) Allow the accumulator to completely dump on its own. Dump any residual pressure by pressing and holding REVOLVING MAGAZINE pushbutton or holding cold recoil jacks handle to the RECOILED position until pressure has been completely dumped.
- (19) Verify the fast ram interlock solenoid (3HY2) de-energizes and the linkage extends to the non-ramming position.
- (20) Set circuit breakers CB1 and CB2 to 0 (off).
- (21) Pull to rear and hold handle of counter rebounding mechanism.
- (22) Use breech manual handwheel to eject rammable round and latch open breech.
- (23) Remove dummy round from breech and verify no firing pin indentation in primer wax.
- (24) Remove and stow handwheel.
- (25) Set circuit breakers CB1 and CB2 to 1 (on).
- (26) Press HYDRAULIC UNIT ON pushbutton.
- (27) Set cold recoil jacks control valve to RECOILED to move recoiling mass to maximum recoil position.

- (28) Set cold recoil jacks control valve to RUN-OUT to allow cold recoil jacks to fully retract and allow recoiling mast to return to hooks position.
- (29) Using screwdrivers, release empty case consent.

WARNING: Stand clear of rocking arms and gun barrel when indexing 2HP1 to ram a round.

- (30) Use T-handle assembly in 2HP1 to manually cycle rocking arms once to ram a round (if fast ram interlock is not installed).

NOTE 6: If fast ram interlock is not installed, omit steps 1.e.(31), 1.e.(32), and 1.e.(34).

- (31) Verify the round indexed onto tray and fast ram interlock is holding the gun (out of battery) at hooks position.
- (32) Actuate the fast ram interlock switch 2S5. Interlock should release gun into battery and ram the round.
- (33) Press HYDRAULIC UNIT OFF pushbutton.
- (34) Verify fast ram interlock solenoid (3HY2) de-energizes and linkage extends to non-ramming position.
- (35) Position circuit breakers CB1 and CB2 to 0 (off).
- (36) Clear training circle of personnel and equipment. Fold down lifelines/other ship equipment necessary to provide clear training and firing zone.

WARNING: Establish communication with safety observer and ensure area is clear before training or elevating gun.

- (37) Establish communications with fire control.

WARNING: Train runaway can occur with gun in remote.

- (38) Position circuit breakers CB1 and CB2 to 1 (on).
- (39) Set LOCAL/REMOTE switch to REMOTE. Verify GUN IN REMOTE green indicating lamp is lit.
- (40) Request from CIC a gun train and elevation order to a known nonfiring zone.
- (41) Request firing circuit be energized in CIC. Close firing key in CIC.
- (42) Request a train order from nonfiring zone to firing zone. Verify firing pin does not release until gun barrel clears nonfiring zone.
- (43) Verify MISFIRE indicating lamp is lit.
- (44) Open firing key in CIC.
- (45) Request CIC secure gun order signals and firing circuit.

NOTE 7: An officer shall witness that the firing cutout solenoid has retracted to the non-firing position (solenoid de-energized) after the firing key is opened.

- (46) Set LOCAL/REMOTE switch to LOCAL. Verify GUN IN REMOTE green indicating lamp is not lit.
- (47) Use TRAIN and ELEVATION switches to train gun mount to normal stow position (may require re-energization of train and elevation power drives).
- (48) Press ELEVATION-OFF and TRAINING-OFF pushbuttons.
- (49) Set circuit breakers CB1 and CB2 to 0 (off).
- (50) Pull to rear and hold handle of counter-rebounding mechanism.
- (51) Use breech manual handwheel to latch open breech.
- (52) Remove rammable dummy round from breech and verify firing pin protrusion by observing indentation in primer wax.
- (53) Remove and stow handwheel.

NOTE 8: Refer to latest NSWC list of effective drawings/certification sheets for latest revision of Gun Pointing and Firing Zone Data Drawings.

NOTE 9: Weapons Officer shall verify results of this maintenance requirement against previously recorded entries in combat systems smooth log to ensure firing cutout zones have not degraded.

NOTE 10: Report any out of tolerance readings to nearest NAVSEACEN representative.

WARNING: After any alteration to ship superstructure, Gun Pointing and Firing Zone Data Drawings must be recertified and approved by a NAVSEACEN representative.

NOTE 11: Any adjustment to the firing cutouts by ships force will be performed only in an EMERGENCY determined by the Commanding Officer.

- (54) Position circuit breakers CB1 to 1 (on).
- (55) Set LOCAL/REMOTE switch to LOCAL. Verify GUN IN LOCAL red indicating lamp is lit.
- (56) Start train and elevation motors.
- (57) Position the gun close to a known NON-FIRING ZONE using train switch S-3 and elevation switch S-6.
- (58) Deenergize train and elevation motors.
- (59) Train (elevate) gun with handcrank into the NON-FIRING ZONE until the FIRING CUTOUT indicator lamp is lit.
- (60) Record train (elevation) position at the synchro box when FIRING CUTOUT indicator lamp is lit.
- (61) Repeat steps 1.e.(56) through 1.e.(60) as necessary to test each nonfiring zone.
- (62) Compare readings to the latest NSWC Gun Pointing and Firing Zone Data Drawings.

NOTE 12: An officer shall witness the inspection of chamber and pass of bore plug gage.

f. Inspect bore and chamber:

- (1) Manually depress gun to accessible position.
- (2) Inspect bore and chamber for flaws.
- (3) Pass bore plug gage; if bore plug gage will not pass, inform maintenance group supervisor.
- (4) Manually elevate gun to stow position.

g. Test barrel cooling system:

- (1) Set circuit breaker CB1 to 1 (on).
- (2) Ensure barrel cooling flexible hose is connected to saltwater line quick-connect coupling at barrel cooling panel.
- (3) Open saltwater manual shutoff valve at barrel cooling control panel. Verify saltwater pressure gauge indicates approximately 7 kg/cm².
- (4) Press BARREL COOLING-ON pushbutton; BARREL COOLING-ON green indicating lamp should be lit.
- (5) Verify barrel cooling system is operating.
- (6) Press BARREL COOLING-OFF pushbutton. Verify barrel cooling system stops, BARREL COOLING-OFF red indicating lamp is lit, and BARREL COOLING-ON green indicating lamp is not lit.

WARNING: To prevent unintentional ramming, do not make empty case consent until instructed by firing procedure. Refer to SM314-AO-MNM-010/GM Mk 75 Mods 0 and 1, table 2-7.

NOTE 13: If actual firing is not conducted, flush barrel cooling system with fresh water.

h. Flush barrel cooling system with fresh water:

- (1) Elevate gun to maximum elevation:
 - (a) Set circuit breaker CB1 to 1 (on).
 - (b) Press ELEVATION ON pushbutton.

WARNING: Establish communication with safety observer and ensure area is clear before moving gun in elevation.

- (c) Use ELEVATION SWITCH to elevate gun barrel to maximum elevation.
 - (d) Press ELEVATION-OFF pushbutton.
 - (e) Set circuit breaker CB1 to 0 (off).
 - (f) Lock safety lock; remove and retain key.
 - (g) Engage elevation securing mechanism.
- (2) Close saltwater manual shutoff valve.
- (3) Connect barrel cooling flexible hose to freshwater quick-connect coupling (if applicable).

NOTE 14: For ships without ORDALT 15191 installed, omit steps 1.h(4), 1.h.(5), and 1.h.(7).

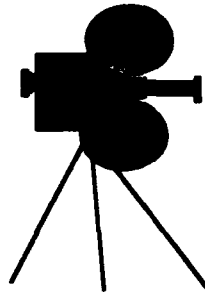
- (4) Set CB1 to 1 (on).
- (5) Press BARREL COOLING-ON pushbutton.
- (6) Open freshwater manual shutoff valve, flush barrel cooling system approximately 5 minutes. Close freshwater manual shutoff valve.
- (7) Press BARREL COOLING-OFF pushbutton.
- (8) Depress gun to -5 degrees to drain gun barrel components:
 - (a) Disengage elevation securing mechanism.
 - (b) Unlock safety lock; set circuit breaker CB1 to (on).
 - (c) Press ELEVATION-ON pushbutton.

WARNING: Establish communication with safety observer and ensure area is clear before moving gun in elevation.

- (d) Use ELEVATION SWITCH to depress gun barrel to -5 degrees.
- (e) Use ELEVATION SWITCH to return gun to stow position.
- (f) Press ELEVATION-OFF pushbutton.
- (g) Set circuit breaker CB1 to 0 (off).
- (h) Lock safety lock; remove and retain key
- (i) Engage elevation securing mechanism.
- (j) Return equipment to readiness condition.

APPENDIX B

76mm/62 Cal Gun Mount Pre-firing Inspections PMS Check R-1



Prepared By:

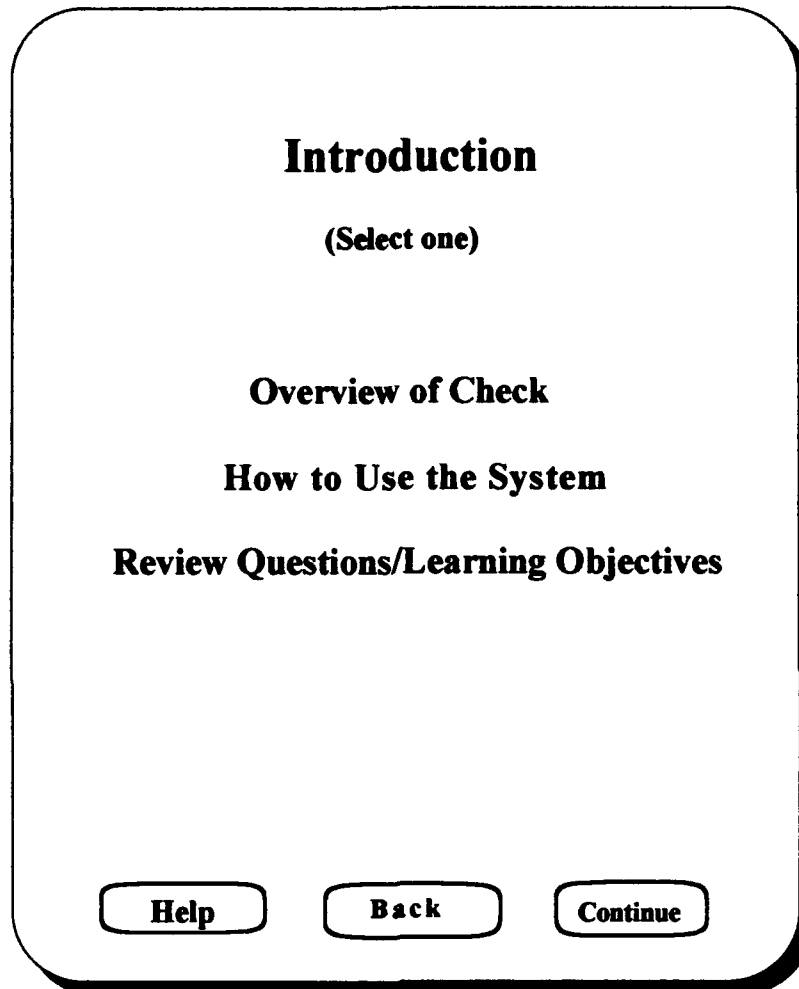
Robert P. Benjamin, Jr., LT, USN

Ira Spondre, CAPT, USMC

Main Menu

Continue

Figure 1. Presentation cover page.

The image shows a software interface for an introduction screen. It is a rounded rectangle with a thick black border. At the top, the word "Introduction" is centered in a bold, black, sans-serif font. Below it, the text "(Select one)" is centered in a smaller, regular, black, sans-serif font. Further down, there are four menu items listed vertically, each centered: "Overview of Check", "How to Use the System", and "Review Questions/Learning Objectives". At the bottom of the screen, there are three buttons arranged horizontally. Each button is a rounded rectangle with a thin black border and contains text in a bold, black, sans-serif font. The buttons are labeled "Help", "Back", and "Continue" from left to right.

Introduction

(Select one)

Overview of Check

How to Use the System

Review Questions/Learning Objectives

Help **Back** **Continue**

Figure 2. Introduction screen.

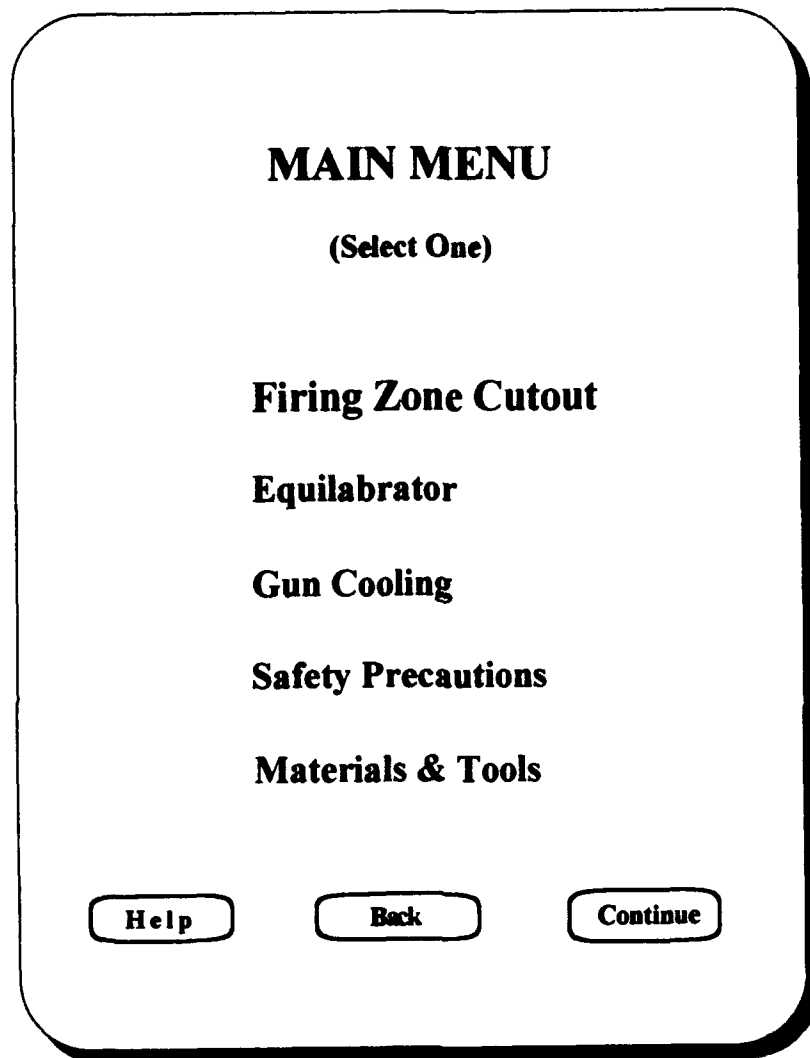


Figure 3. Main menu screen.

Ship System Guns & Ammunition	Subsystem Guns & Mounts	MRC Code 7111 R-1	
System Guns	Equipment MK 75 Mod 0, 1, 76mm/ 62 Cal Gun Mount 71112V	Rates Weps Off GMG3 2GMGSN	M/H 1.0 2.0
Maintenance Requirement Description Perform Pre-Firing Inspection		Total M/H 3.0	
		Elapsed Time 1.0	

Select one of the following Subsystems:

Safety Subsystem

Communication Subsystem

Gun Preparation Subsystem

Main Menu **Back** **Continue**

Figure 4. Firing zone portion header screen.

SAFETY SUBSYSTEM

(Learning Objectives)

- 1. Be familiar with safety precautions contained in SW314-AO-MMM-010 through -40.**
- 2. Know who must authorize a tagout..**
- 3. Know who must be notified before check is begun.**
- 4. Know how to prevent unintentional raming of dummy round.**
- 5. Know why accumulator pressure must be dumped before beginning check.**

These objectives are presented as examples only.

Main Menu

Back

Continue

Figure 5. Safety subsystem learning objectives screen.

SAFETY SUBSYSTEM

(Questions)

This screen will present five multiple choice questions. Each incorrect answer will launch a presentation that is designed to lead the user to the correct answer and explain why the chosen answer is incorrect. Review replays this portion of the presentation.

Main Menu

Review

Help

Figure 6. Test question screen.

Perform Pre-firing Inspection

Safety Precautions

- 1. Forces afloat comply with NAVOSH program manual
Forces Afloat, OPNAVINST 5100.19 series.**
- 2. Observe safety precautions contained in SW314-AO-
MMM-010 through 040/GM Mk75 Mods 0 and 1.**
- 3. Injury to personnel or damage to equipment may result
if accumulator pressure is not dumped to tank.**

Main Menu

Back

Continue

Figure 7. Firing zone portion safety precautions screen 1.

Perform Pre-firing Inspection

Safety Precautions

- 4. Ensure personnel are clear of gun loading equipment before and while operating gun loading equipment.**
- 5. Stand clear of rocking arms and gun barrel when indexing 2HP1 to ram round.**
- 6. Establish communications with safety observer and ensure area is clear before training or elevating gun.**

Main Menu

Back

Continue

Figure 8. Firing zone portion safety precautions screen 2.

Perform Pre-firing Inspection

Safety Precautions

- 7. Train runaway can occur with gun in remote.**
- 8. After any alteration to ship superstructure, Gun Pointing and Firing Zone Data Drawings must be recertified and approved by a NAVSEACEN representative.**
- 9. To prevent unintentional ramming, do not make empty case consent until instructed by firing procedure. Refer to SW314-AO-MMM-010/GM Mk 75 Mods 0 and 1, table 2-7.**

Main Menu

Back

Continue

Figure 9. Firing zone portion safety precautions screen 3.

HELP

These screens should vary dependent upon their location within the document. Some screens will present full motion video presentations while others should be strictly text or text and pictures. dependent upon the concept being presented.

Return

Figure 10. Generic help screen.

APPENDIX C

1. MK-75 Adjustment
2. MK-75 Alignment
3. MK-75 Breech Removal
4. MK-75 Operations
5. MK-75 Safety Summary Training

LIST OF REFERENCES

- Bagget, P., Understanding Visual and Verbal Messages. In H. Mandl and J. Levin (Eds.), *Knowledge Acquisition from Text and Pictures* (pp. 101-124), Amsterdam: Elsevier..
- Baggett, P., "Role of Temporal Overlap of Visual and Auditory Material in Forming Dual Media Associations", *Journal of Educational Psychology*, Vol. 76, No. 3, 1984, pp. 408-417.
- Blattner, M. and Dannenberg, R., *Multimedia Interface Design*, Addison-Wesley Publishing Company, 1992.
- Braby et al., "A Technique for Choosing Cost Effective Instructional Delivery Systems", TAEG Report No. 16, Naval Training Equipment Center, April 1975.
- Card, S. and Moran, T., and Newell, A., *The Psychology of Human-Computer Interaction*, Lawrence Erlbaum Associates, Hillsdale, New Jersey, London, 1983.
- Chabay, R. W., and Sherwood, B. A. (1992), A Practical Guide for the Creation of Educational Software. In J. H. Larkin and R. W. Chabay (Eds.), *COMPUTER-ASSISTED INSTRUCTION and INTELLIGENT TUTORING SYSTEMS: Shared Goals and Complementary Approaches* (pp. 151-186). Hillsdale, NJ: Lawrence Erlbaum Associates.
- Clark, R., "Reconsidering Research on Learning from Media", *Review of Educational Research*, Vol. 53, No. 4, 1983, pp. 445-459.
- Department of the Navy Maintenance Requirement Card, OPNAV 4790 (REV. 2-92) 710-7111-R-1, *Guns and Ammunition: Guns and Mounts, MK 75 Mod 0,1, 76mm 62 Cal Gun Mount 71112V*, April 1992.
- Drapeau, G. and Greenfield, H., *MAEstro-Adistributed Multimedia Authoring Environment*, Stanford University, 1992.
- Filbert, D. and Weatherspoon, J., *Cognitive psychology and Design Paradigms in the Development of Multimedia Courseware*, Master's Thesis, Naval Postgraduate School, Monterey, California, September 1993.
- Frame Technology Corporation, *FrameMaker Reference*, September 1990.
- Glaser, R., "Education and Thinking: The Role of Knowledge", *American Psychologist*, Vol. 39, No. 2, 1984, pp. 93-104.
- Glaser, R. and Bassok, M., "Learning Theory And The Study Of Instruction", *Annual Review of Psychology*, Annual Reviews, 1989, pp. 631-666.

Gagne', R. M. and Glaser, R. (1987), *Foundations in Learning Research*. In R. M. Gagne' (Ed.), *Instructional Technology: Foundations* (pp. 49-84), Hillsdale, NJ: Lawrence Erlbaum Associates.

Hapeshi, K. and Jones, D., "Interactive Multimedia for Instruction: A Cognitive Analysis of the Role of Audition and Vision", *International Journal of Human-Computer Interaction*, Vol. 4, No. 1, 1992, pp. 79-99.

Hegarty, M. and Just, M. A., *Understanding Machines from Text and Diagrams*. In H. Mandl and J. Levin (Eds.), *Knowledge Acquisition from Text and Pictures*, Amsterdam: Elsevier, pp. 171-194.

Kozma, R.B., "Learning with Media", *Review of Educational Research*, Vol. 61, No. 2, Summer 1991, pp. 179-211.

Kribs, H. D., Simpson, A. C. and Mark, L. J., "Automated Instructional Media Selection", Technical Report: NAVTRAEQUIPCEN 79-C-0104-1, Instructional Science and Development, Inc., October, 1983.

LaBarge, D. and Samuels, S. J., "Toward a Theory of Automatic Information Processing in Reading", *Cognitive Psychology*, Vol. 6, 1974, pp. 293-323.

McDowd, J. and Botwinick, J., "Rote and Gist Memory in Relation to Type of Information, Sensory Mode, and Age", *The Journal of Genetic Psychology*, Vol. 145, No. 2, 1984, pp. 167-178.

Nielsen, J., *HyperText & HyperMedia*, San Diego: Academic Press, 1990.

Nugent, G., "Pictures, Audio, and Print: Symbolic Representation and Effect on Learning", *ECTJ*, Vol. 30, No. 3, pp. 163-174.

Olson D. et al., *Media and Symbols: The Forms of Expression, Communications, and Education*, Chicago: The National Society for the Study of Education, 1974.

Parallax Graphics, Inc., *XVIDEO Users Guide*, 1991.

Rustead, R. and Coltheart, V., "The Effect of Pictures on the Retention of Novel Words and Prose Passages", *Journal of Experimental Child Psychology*, Vol. 28, 1979, pp. 516-524.

Salomon, G. and Clark, R., "Reexamining the Methodology of Research on Media and Technology in Education", *Review of Educational Research*, Vol. 47, No. 1, Winter 1977, pp. 99-120.

Salomon, G., *Interaction of Media, Cognition, and Learning*, San Francisco: Jossey-Bass, Inc., 1979.

Sanders, M. and McCormick, E., *Human Factors in Engineering and Design*, 7th Ed., McGraw-Hill, Inc., 1993

Shneiderman, B., *Designing the User Interface: Strategies for Effective Human-Computer Interaction*, 2nd Ed., Addison-Wesley Publishing Co., 1992.

Stone, D. and Glock, M., "How do Young Adults Read Directions With and Without Pictures", *Journal of Educational Psychology*, Vol. 73, No. 3, 1981, pp. 419-426.

Sun Microsystems, Inc., *Open Windows Users Guide*, 1990.

Sun Microsystems, Inc., *SPARCstation 10, Installation Guide*, 1991.

The Merriam-Webster Dictionary, Pocket Books, 1978.

BIBLIOGRAPHY

- Anderson, J. and Milson, R., "Human Memory: An Adaptive Perspective", *Psychology Review*, Vol. 96, No.4, 1989, pp. 703-719.
- Baek, Y. K. and Layne, B. H., "Color, Graphics, and Animation In A Computer-Assisted Learning Tutorial Lesson", *Journal of Computer-Based Instruction*, Vol. 15, No. 4, Autumn 1988, pp. 131-135.
- Bagget, P., Understanding Visual and Verbal Messages. In H. Mandl and J. Levin(Eds.), *Knowledge Acquisition from Text and Pictures*, Amsterdam: Elsevier, pp. 101-124.
- Baggett, P., "Role of Temporal Overlap of Visual and Auditory Material in Forming Dual Media Associations", *Journal of Educational Psychology*, Vol. 76, No. 3, 1984, pp. 408-417.
- Barker, P., "Designing Interactive Learning Systems", *Educational & Training Technology International*, Vol.27, No.2, May 1990, pp. 125-145.
- Benest, I., "An Alternative Approach to Hypertext", *Educational & Training Technology International*, Vol. 28, No. 4, Nov. 1991, pp. 341-346.
- Bingham, M., "Results of Two Studies on the Benefits and Pitfalls of Technology-based Information Accessing", *Technological Horizons in Education*, Vol. 20, No. 4, Nov. 1992, pp. 88-92.
- Blattner, M. and Dannenberg, R., *Multimedia Interface Design*, Addison-Wesley Publishing Company, 1992.
- Braby et al., "A Technique for Choosing Cost Effective Instructional Delivery Systems", TAEG Report No. 16, Naval Training Equipment Center, April 1975.
- Bransford, J. and Johnson, M., "Contextual Prerequisites for Understanding: Some Investigations of Comprehension and Recall", *Journal Of Verbal Learning And Verbal Behavior* 11, 1972, pp.717-726.
- Burns, R., "Designing Presentations to Help Students Remember", *JCST*, March/April 1990, pp. 301-
- Card, S. and Moran, T., and Newell, A., *The Psychology of Human-Computer Interaction*, Lawrence Erlbaum Associates, Hillsdale, New Jersey, London, 1983.
- Chabay, R. W., and Sherwood, B. A. (1992), A Practical Guide for the Creation of Educational Software. In J. H. Larkin and R. W. Chabay(Eds), *COMPUTER-ASSISTED*

INSTRUCTION and INTELLIGENT TUTORING SYSTEMS: Shared Goals and Complementary Approaches (pp. 151-186). Hillsdale, NJ: Lawrence Erlbaum Associates.
Clark, R., "Reconsidering Research on Learning from Media", *Review of Educational Research*, Vol. 53, No. 4, 1983, pp. 445-459.

Copeland, P., "The Multimedia Mix", *Educational & Training Technology International*, Vol. 28, No. 2, May 1991, pp. 154-163.

Department of the Navy Maintenance Requirement Card, OPNAV 4790 (REV. 2-92) 710-7111-R-1, *Guns and Ammunition: Guns and Mounts, MK 75 Mod 0,1, 76mm 62 Cal Gun Mount 71112V*, April 1992.

Drapeau, G. and Greenfield, H., *MAestro-Adistributed Multimedia Authoring Environment*, Stanford University, 1992.

Falk, D. R. and Carlson, H., "Learning to Teach With Multimedia", *Technological Horizons In Education Journal*, Vol. 20, No. 2, Sept. 1992, pp. 96-101.

Filbert, D. and Weatherspoon, J., *Cognitive psychology and Design Paradigms in the Development of Multimedia Courseware*, Master's Thesis, Naval Postgraduate School, Monterey, California, September 1993.

Frame Technology Corporation, *FrameMaker Reference*, September 1990.

Gagne', R. M. and Glaser, R. (1987), *Foundations in Learning Research*. In R. M. Gagne' (Ed.), *Instructional Technology: Foundations* (pp. 49-84), Hillsdale, NJ: Lawrence Erlbaum Associates.

Glaser, R., "Education and Thinking: The Role of Knowledge", *American Psychologist*, Vol. 39, No. 2, 1984, pp. 93-104.

Glaser, R. and Bassok, M., "Learning Theory And The Study Of Instruction", *Annual Review of Psychology*, Annual Reviews, 1989, pp. 631-666.

Goodman, B., "Multimedia Explanations for Intelligent Training Systems", 1991 Conference on Intelligent Computer-Aided Training, Houston, Tx.

Gotz, K., "Interactive Learning with the Computer", *Educational & Training Technology International*, Vol. 28, No. 1, Feb. 1991, pp. 7-14.

Hapeshi, K. and Jones, D., "Interactive Multimedia for Instruction: A Cognitive Analysis of the Role of Audition and Vision", *International Journal of Human-Computer Interaction*, Vol. 4, No. 1, 1992, pp. 79-99.

Hayes, D., Kelly, S. B., and Mandel, "Media Differences in Children's Story Synopses: Radio and Television Contrasted", *Journal of Educational Psychology*, Vol. 78, No. 5, 1986, pp. 341-346.

Hegarty, M. and Just, M. A., *Understanding Machines from Text and Diagrams*. In H. Mandl and J. Levin(Eds.), *Knowledge Acquisition from Text and Pictures*, Amsterdam: Elsevier, pp. 171-194.

Huston, A. and Wright, J., *Children's Processing of Television: The Informative Functions of Formal Features*. In S. Bryant and D. R. Anderson(Eds.), *Children's Understanding of Television*, New York: Academic Press, pp. 35-68.

Kidd, M. R., Hutchings, G. A. and Hall, W., Cesnik, B. "Applying Hypermedia to Medical Education: An Author's Perspective", *Educational & Training Technology International*, Vol. 29, No. 2, May 1992, pp. 143-151.

Kintsch, W. and van Dijk, T. A., "Toward a Model of Text Comprehension and Production", *Psychology Review*, Vol. 85, No. 5, Sept. 1978, pp. 363- 394.

Kintsch, W.(1989). *Learning from Text*. In L. B. Resnick(Ed.), *Knowing, Learning, and Instruction: Essays in Honor of Robert Glaser* (pp. 25-46). Hillsdale, NJ: Lawrence Erlbaum Associates.

Kozma, R.B., "Learning with Media", *Review of Educational Research*, Vol. 61, No. 2, Summer 1991, pp. 179-211.

Kribs, H. D., Simpson, A. C. and Mark, L. J., "Automated Instructional Media Selection", Technical Report: NAVTRAEQUIPCEN 79-C-0104-1, Instructional Science and Development, Inc., October, 1983.

LaBarge, D. and Samuels, S. J., "Toward a Theory of Automatic Information Processing in Reading", *Cognitive Psychology*, Vol. 6, 1974, pp. 293-323.

Larkin, J. and Chabay, R., *Computer-Assisted Instruction and Intelligent Tutoring Systems: Shared Goals and Complementary Approaches*, Hillsdale, NJ: Lawrence Erlbaum Associates, 1992.

Main, R. E. and Daira, P., "Guidelines for the Development of Military Training Aids", Naval Personnel Research and Development Center, San Diego, Ca., Jul. 1988.

McDowd, J. and Botwinick, J., "Rote and Gist Memory in Relation to Type of Information, Sensory Mode, and Age", *The Journal of Genetic Psychology*, Vol. 145, No. 2, 1984, pp. 167-178.

Midoro, E. F. and Pedemonte, G. M., "Do Hypermedia Systems Really Enhance Learning? A Case Study on Earthquake Education", *Educational & Training Technology International*, Vol. 29, No. 1, Feb. 1992, pp. 42-51.

Milheim, W. D., "The Effects of Pacing and Sequence Control in an Interactive Video Lesson", *Educational & Training Technology International*, Vol. 27, No. 1, Feb. 1990, pp. 7-19.

Nielsen, J., *HyperText & HyperMedia*, San Diego: Academic Press., 1990.

Norman, D. and Hutchins, E., "Computation via Direct Manipulation", Final Report: Office of Naval Research N00014-85-C-0133, Institute for Cognitive Science, University of California, San Diego, Aug., 1988.

Nugent, G., "Pictures, Audio, and Print: Symbolic Representation and Effect on Learning", *ECTJ*, Vol. 30, No. 3, pp. 163-174.

Olson D. et al., *Media and Symbols: The Forms of Expression, Communications, and Education*, Chicago: The National Society for the Study of Education, 1974.

Parallax Graphics, Inc., *XVIDEO Users Guide*, 1991.

Reeves, T., "Evaluating Interactive Multimedia", *Educational Technology*, May 1992, pp. 47-53.

Reiser, R., Gagne, R., Wagner, W., Larsen, J., Hewlett, B., Noel, K., Winner, J., and Fagen, C., "A Learning-Based Model For Media Selection: Media Selection Flowchart and User's Guide", U.S. Army Research Institute For The Behavioral And Social Sciences, Alexandria, Va., Mar. 1981.

Riding, R. and Chambers, P., "CD-ROM versus Textbook: A Comparison of the Use of Two Learning Media by Higher Education Students", *Educational & Training Technology International*, Vol. 29, No. 4, Nov. 1992, pp. 342-349.

Reiser, R. and Gagne', R., "Characteristics of Media Selection Models", *Review of Educational Research*, Vol. 52, No. 4, Winter 1982, pp. 499-512.

Rieber, L., "Animation, Incidental Learning, and Continuing Motivation", *Journal of Educational Psychology*, Vol. 83, No. 3, 1991, pp. 318-328.

Rieber, L. and Kini, A., "Theoretical Foundations of Instructional Applications of Computer-Generated Animated Visuals", *Journal of Computer-Based Instruction*, Vol. 18, No. 3, Summer 1991, pp. 83-88.

Rieber, L. P., Boyce, M. J. and Assad, C., "The Effects of Computer Animation on Adult Learning And Retrieval Tasks", *Journal of Computer-Based Instruction*, Vol. 17, No. 2, Spring 1990, pp. 46-52.

Romiszowski, A. J., *Developing Auto-Instructional Materials*, New York: Nichols Publishing, 1986.

Rustead, R. and Coltheart, V., "The Effect of Pictures on the Retention of Novel Words and Prose Passages", *Journal of Experimental Child Psychology*, Vol. 28, 1979, pp. 516-524.

Salomon, G. and Clark, R., "Reexamining the Methodology of Research on Media and Technology in Education", *Review of Educational Research*, Vol. 47, No. 1, Winter 1977, pp. 99-120.

Salomon, G., *Interaction of Media, Cognition, and Learning*, San Francisco: Jossey-Bass, Inc., 1979.

Sanders, M. and McCormick, E., *Human Factors in Engineering and Design, 7th Ed.*, McGraw-Hill, Inc., 1993.

Shneiderman, B., *Designing the User Interface: Strategies for Effective Human-Computer Interaction*, 2nd Ed., Addison-Wesley Publishing Co., 1992.

Stone, D. and Glock, M., "How do Young Adults Read Directions With and Without Pictures", *Journal of Educational Psychology*, Vol. 73, No. 3, 1981, pp. 419-426.

Sun Microsystems, Inc., *Open Windows Users Guide*, 1990.

Sun Microsystems, Inc., *SPARCstation 10, Installation Guide*, 1992.

Tannenbaum, S. and Yukl, G., "Training And Development In Work Organizations", *Annual Review of Psychology*, Vol. 43, 1992, pp. 399-441.

The Merriam-Webster Dictionary, Pocket Books, 1978.

Van Dam, A., "The electronic classroom: workstations for teaching", *International Journal for Man-Machine Studies*, Vol. 21, 1984, pp. 353-363.

INITIAL DISTRIBUTION LIST

	No. copies
1. Defense Technical Information Center Cameron Station, Alexandria, Virginia 22304-6145	2
2. Director, Training and Education MCCDC, Code C46 1019 Elliot Road Quantico, Virginia, 22134-5207	1
3. Library, Code 52 Naval Postgraduate School Monterey, California 93943-5002	2
4. Curricular Officer, Code 37 Naval Postgraduate School Monterey, California 93943-5000	1
5. Prof. Kishore Sengupta, Code AS/Se Naval Postgraduate School Monterey, California 93943-5002	1
6. Prof. B. Ramesh, Code AS/Ra Naval Postgraduate School Monterey, California 93943-5002	1
7. CAPT. Ira Spondre 14418 Seagate Drive San Leandro, California 94577	1
8. LT. Robert Benjamin 13349 Currituck Drive North Jacksonville, Florida 32225	5
9. LT. Jamel Weatherspoon 82 Burnside Avenue Newport, Rhode Island 02840	1